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Gas transfer in air-lifts used to recirculate aquaculture systems

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GAS TRANSFER IN AIR-LIFTS USED TO RECIRCULATE AQUACULTURE SYSTEMS

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ABSTRACT

The following studies were conducted to determine hydraulic, aeration, and degasification characteristics associated with various air-lift pumps. The first study presented data on a 20.3 cm air-lift used to support adult Yellowtail broodstock (*Seriola lalandi*) in an oligotrophic warmwater marine RAS (recirculating aquaculture system). Empirical relationships were used to estimate actual oxygen and carbon dioxide mass transfer rates (AOTR & ACTR) as the inlet oxygen or carbon dioxide concentrations were perturbed under lift heights of 30.5, 38.1, and 45.7 cm. Transfer rates, kg of constituent per day, were found to be dependent on air injection depth and volume, aqueous gas concentrations, and lift height. Liquid flows ranged from 623 – 1,117 l min^{-1} for corresponding air injections of 850 – 1,415 l min^{-1}. Certain extremities show the tested air-lift capable of providing 3.13 kg O_2 day^{-1} while concurrently stripping 28.32 kg CO_2 day^{-1}.

The second study examined standard oxygen and carbon dioxide transfer rates (SOTR & SCTR) for 10.2, 15.2, and 20.3 cm SUTA (siphoning u-tube air-lift) pumps in low-head, freshwater recirculation systems. Results varied as pipe diameter, gas to liquid ratios, and lift to submergence ratios varied; with transfer rates increasing with pipe diameter and air injection volume. SOTR values ranged from 0.0594 kg O_2 hr^{-1} to 0.2073 kg O_2 hr^{-1} while SCTR varied between 0.0013 to 0.0061 kg CO_2 hr^{-1}. All configurations were capable of stripping CO_2 less than 20 mg l^{-1} while targeting DO levels of 5 mg l^{-1}.

Steady state analysis shows that 20.3 cm air-lifts can meet O_2 consumption and CO_2 production rates of broodstock, fingerling, and growout categories in warmwater marine environments. As feed rate varied from 4 to 17 kg feed day^{-1}, oxygen and carbon dioxide levels were sufficiently maintained for broodstock and fingerlings, with supplemental air recommended for growout conditions.

CHAPTER 1: INTRODUCTION

Over the years, aquatic facilities have attempted numerous technological approaches as stratagems to the increasing seafood market demand and dwindling ocean supply. As water availability concerns and stringent discharge requirements are becoming more problematic, Aquaculturists are forced to resort to alternate and more robust technologies, including recirculating aquaculture systems (RAS). Timmons et al. (2001) state recirculating aquaculture systems generally conserve greater then 90% of the water as compared to more traditional setups. They are fundamentally conditioned to maximize existing water use, creating a need for continuous water circulation and high degrees of water treatment. Nevertheless, there are several basic concepts that are clearly defined for recirculating units, with the majority of literature agreeing with the related assumptions and principles:

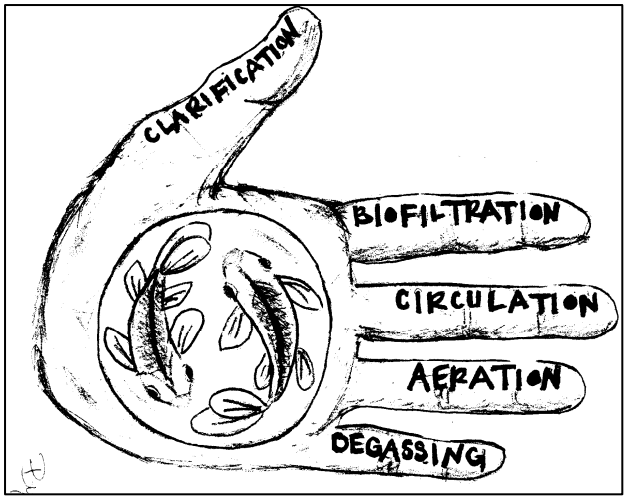


Figure 1-1. The five fundamental recirculation requirements (adapted from Malone and Gudipati, 2005a).

1. RAS were implemented for water and land conservation, intensive stocking capacities, and bio-security concerns.
2. Five fundamental fingers of recirculation must be addressed (Figure 1-1); including water circulation, solids capture and removal, oxygen regeneration, carbon dioxide removal, and bio-filtration.
3. Their continuous water movement for oxygen replenishment and waste removal creates an energy intensive environment, permitting higher capital and operating costs for the associated technology.

4. Simpler guidelines, further consolidation of treatment processes, and more energy efficient devices are needed for commercial expansion.

Low-head centrifugal or air-lift pumps are the most common choices for recirculation of waters through the water treatment block in a recirculating system. Centrifugal pumps are extremely efficient at water movement, but they must be matched with the treatment components through their pump curve that relates flow delivery with the expected headlosses. Savings in capital and operating costs for such single components serving multiple duties can overcome the losses seen from individual process inefficiencies. Air-lifts have been successfully utilized in recirculation systems due to their circulation, aeration, and degasification capabilities (Loyless and Malone, 1998).

Air-lift pumps are self-contained liquid transport devices capable of delivering large quantities of water, but are generally only used in systems specifically designed for their use, i.e. low-lift conditions. Serially placed air-lifts can lift water several feet, but they are not particularly efficient. Once the design variables are understood, they are easily constructed from readily available PVC piping. Figure 1-2 shows a common air-lift sketch receiving of a side injected air tube.

The construction of an air-lift consists in its simplest form of an open-ended submerged pipe fitted with a receiving air injection source near the bottom, either by side or concurrent injection. As gas is injected, typically surrounding air from a centrifugal blower, the specific gravity of the gas/water mixture lowers and eventually discharges out the head piece (Wheaton, 1977). There are several fundamental parameters that control the performance of an air-lift, and even slight variations may cause dramatic changes in efficiency. Nicklin (1963) concluded that air injection, pipe size, lift height, and submergence depths control the overall performance of an air-lift.

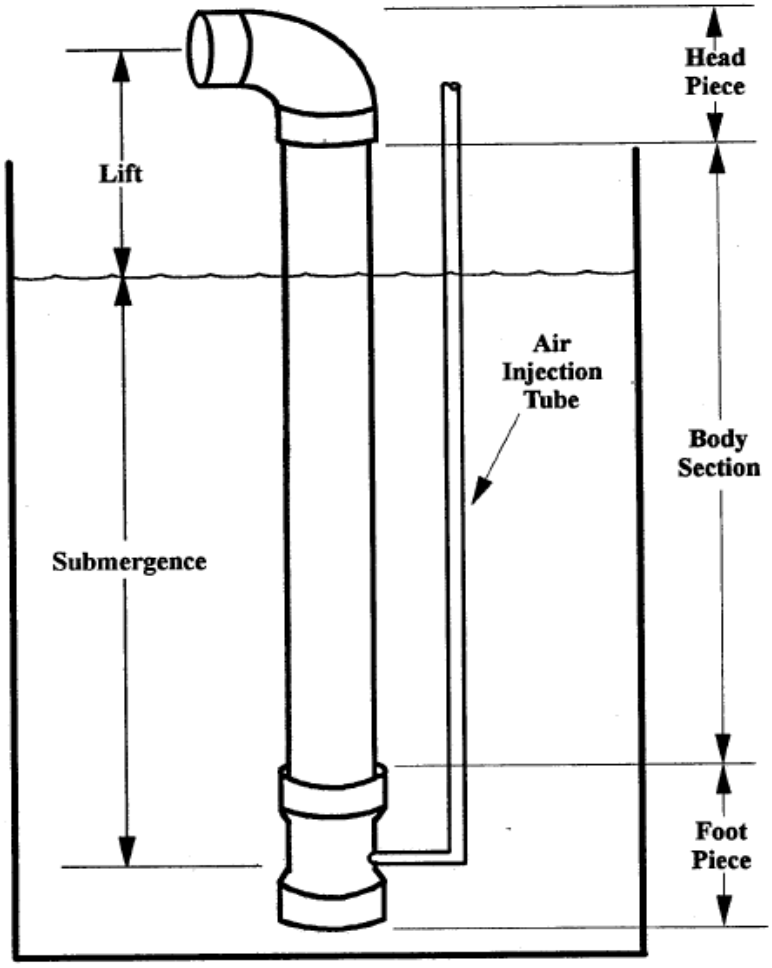


Figure 1-2. Basic schematic of an air-lift pump from Loyless (1995) displaying lift height, submergence, and air injection tube.

The amount of lift and submergence is significant to air-lift placement and operation. As referred to in Figure 1-2, lift height represents the vertical distance above the water surface to the set discharge point (shown as centerline of the headpiece). Submergence is seen as the distance below the water source to the point of air injection. Together, submergence to lift ratio (S:L) represents the submergence depth to the lift height. Percent lift and percent submergence are also helpful when developing air-lifts, and determined by Eq. 1-1 and Eq. 1-2.

$$\%\ Lift = \frac{LiftHeight}{(\ LiftHeight + Submergence\ )} \qquad \textbf{Eq. 1-1}$$

$$\%\ Sub = \frac{Submergence}{(\ LiftHeight + Submergence\ )} \qquad \textbf{Eq. 1-2}$$

Air-lifts are said to be most efficient in applications between 65-75% submergence (Wheaton, 1977). More recent literature reports maximum pumping efficiencies at the higher end, around 80% (Timmons et al., 2001). Malone and Gudipati (2005b) developed very conservative aquacultural guidelines, stating submergence to lift ratios should be kept in the range of 4 to 5. Nevertheless, a standard guideline helps determine the required submergence for a known lift height. For example, if an air-lift is going to operate at 12 inches of lift, the corresponding submergence would require 48 inches for a 20% lift, 80% submergence, or a 4:1 S:L ratio.

Gas to liquid flow ratio (Q_G:Q_L) is a defining characteristic that determines the energy efficiency of the system and a major factor controlling the gas transfer (oxygen in, carbon dioxide out) performance. The ratio represents the amount of air input needed for the resulting liquid discharge. A Q_G:Q_L ratio of 2:1 would require 850 l min^{-1} air injection if the desired liquid flow was 425 l min^{-1}. It is generally more desirable for aquaculture facilities to operate air-lifts at lower Q_G:Q_L ratios from an energy consumption outlook. Malone and Gudipati (2005b), Todoroki et al. (1973), Johnson (2008), and Loyless and Malone (1998) all recommend 1:1 to 2:1 ratios for optimum air-lift performance in low-head aquatic applications. For sufficient CO_2 stripping, larger Q_G:Q_L ratios in the range of 5:1 to 10:1 are typically needed, but generally not seen in air-lifts due to energy costs, water splurging, and decreased efficiencies. Conversely, ratios near 3:1 and slightly lower generally provide for sufficient aeration (Timmons et al., 2001). However, gas to liquid ratios in the 1:1 to 2:1 range have proven to manage sufficient oxygen and carbon dioxide levels (Paquette et al., 2009* in press).

Pipe diameter also contributes to the overall air-lift performance. A wide variety of studies have seen air-lift applications up to 12 inches in diameter. As expected, larger pipes will produce greater liquid flows as a result of increased cross-sectional area and air requirements. Larger pipes also allow for increased interaction between air/water contact times enhancing gas transfer. Malone and Gudipati (2005b) also made recommendations for sizing air-lifts in sequence with PolyGeyser® bio-filters, citing velocity requirements at 0.31 m sec^{-1} (1 ft sec^{-1}). Coupled with a water distribution pipe sizing chart, one can easily determine the pipe size needed for a required liquid flow. For example, a 4 inch air-lift would require 40 gal water min^{-1} to achieve 0.31 m sec^{-1}, and would require 80 gal air min^{-1} to operate at a Q_G:Q_L ratio of 2:1.

Lastly, air-lift performance and ensuing gas transfer are largely manipulated by bubble size characteristics (Wheaton, 1977). The classical interpretation by Barnea and Taitel (1986) of the three most common air-lift flow patterns is shown in Figure 1-3, portraying two phase vertical flows represented by bubble, bubbly-slug, and slug flow. The bubble flow pattern is usually a result of lowered rates of air injection or diffused types of injection devices, such as air-stones. Little interactions between the bubbles are witnessed as they are well distributed over the riser pipe. Gas transfer is greater in this regime, but unsuccessful in producing the desired liquid flows for most recirculation systems.

Increased air injection and open-ended injection ports result in bubbly-slug and slug flows, the two most commonly found in air-lift usage. The intense interaction between increased gas flow generates larger bubbles, characterized as slug formations, where smaller bubbles are found perched behind and dispersed in between slug particles (Reinemann and Timmons, 1989).

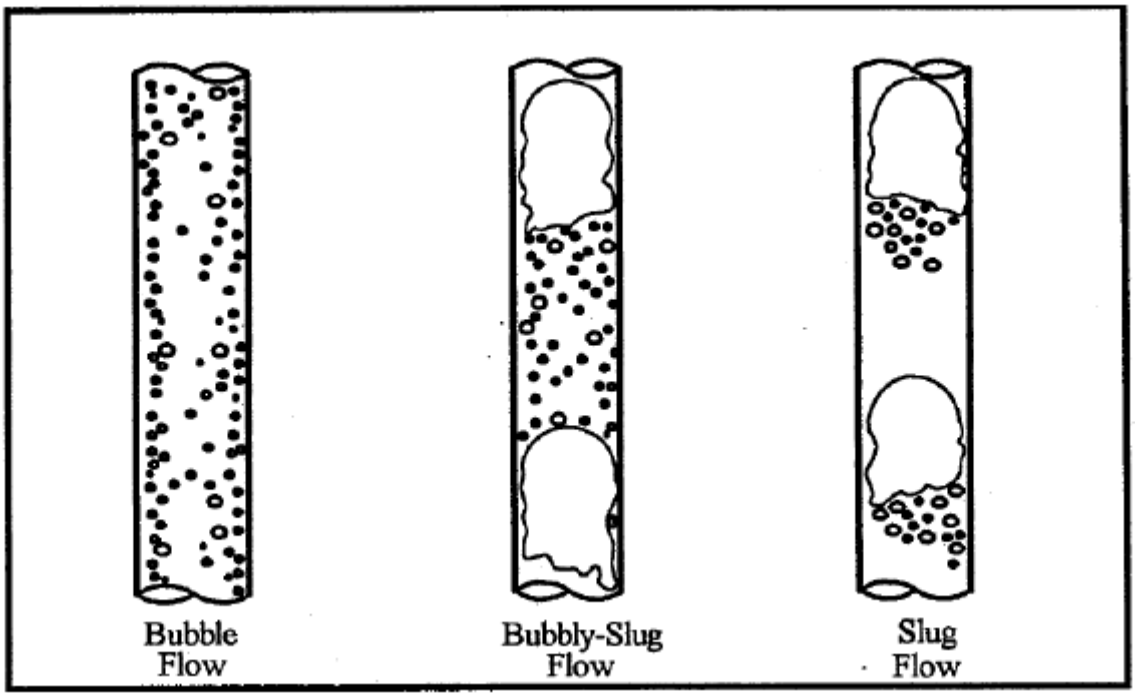


Figure 1-3. Transition as air injection increases for the three most common air-lift two-phase flow regimes.

OBJECTIVES

Design guidelines for gas exchange performance in air-lifts is fairly limited, particularly for CO_2 removal, and propagated the following objectives for study and clarification. Hydraulic, aeration, and degasification performance capabilities for various air-lift configurations were the main focus in this thesis work. The objectives of each chapter are listed:

CHAPTER 2: To determine the relationships between air input, headloss, water flow, oxygen addition (aeration), and carbon dioxide removal (degasification) for 20.3 cm air-lifts in conjunction with a PolyGeyser® bio-filter in a marine oligotrophic recirculation system.

CHAPTER 3: To measure the rates of water movement and CO_2 and O_2 mass transfer in low head freshwater operations for commonly sized PVC pipes ranging from 10.2 to 20.3 cm.

CHAPTER 4: To incorporate the experimental results into a steady state mass balance analyzing air-lift dissolved gas management for broodstock,

fingerling, and growout conditions. The results will determine if the supporting air-lift configuration can withstand the oxygen and carbon dioxide requirements for the varying feed densities as related to each application.

CHAPTER 2: AIR-LIFT KINETICS FOR CARBON DIOXIDE AND OXYGEN IN A MARINE RECIRCULATING AQUACULTURE SYSTEM

INTRODUCTION

Recirculating aquaculture systems' (RAS) water reconditioning processes have made them a popular choice among aquaculture facilities. Historic drawbacks associated with high energy consumption for continuous water circulation and extensive water treatments have limited their expansion. Adoption of air-lifted PolyGeyser® combinations have been noted as more compact and energy efficient tools for use in recirculation systems (Gudipati, 2005b). They provide treatment for a RAS's fundamental processes; water circulation, gas transfer, solids capture, and bio-filtration (Johnson, 2008). Floating bead filters (FBFs) were implemented in the 90's as a solids capture and bio-clarification device, but were generally driven by low head centrifugal pumps. PolyGeyser® floating bead filters, subject to high frequency washing, and packed with reformed plastic media, display headloss characteristics compatible for air-lift operations. The air-lift consolidates several processes into a single unit, supporting water movement and supplemental forms of oxygen delivery and carbon dioxide removal. Reinemann (1987) stated the energy usage for an air-lift for circulation and aeration are close to one-third the cost of a centrifugal pump and aeration system. Further quantification and refinement of their behavior will help develop cost effective design guidelines for commercial applications.

Malone and Pfeiffer (2006) argue the marine oligotrophic classification a distinct aquaculture category requiring a unique set of design criteria. While considerable progress has been made in marine facilities (Davis and Arnold, 1998; Howerton, 2001; Mozes et al., 2003), further development will help simplify the appropriate sizing of RAS components. Hubbs-Sea World Research Institute (HSWRI) undertook a project to support broodstock maturation for California

yellowtail (*Seriola lalandi*) under marine oligotrophic conditions. The target of the research was to evaluate the performance of an air-lifted PolyGeyser® FBF configuration. The focus of this article, however, was placed solely on the air-lift and its performance characteristics, i.e. assessment of the hydraulic behavior along with the oxygen and carbon dioxide transfer.

BACKGROUND

Air-lift pumps consist of a partially submerged pvc pipe fitted with an air injection received at some specified entry point near the bottom (see Figure 2-1). Once air is injected into the lift pipe the density of the air/water mixture drops and allows the water to eventually come to a certain discharge level. The discharge level is typically set at centerline of the outlet device, shown in Figure 2-1 as a PVC 'T'.

Representation [A] shows the air-lift is non-operational, and submergence is defined as the total distance from injection point to the water surface. As air is injected, seen in [B], headlosses are incurred and total lift is represented as dynamic lift, which incorporates all frictional losses associated with pipes, fittings, filter media, and other obstructions of flow. The frictional losses encountered are measured through pitot tubes, clear flexible tubing installed just before air injection. Submergence is the remaining vertical distance between the air injection and point of measurement on the pitot tube. The total submergence to lift (S:L) controls, in part, the hydraulic performance of the airlift.

Gas to liquid flow ratio (Q_G:Q_L) is another factor controlling air-lift operation (Reinemann and Timmons, 1989 and Wheaton, 1977). Malone and Gudipati (2005b) suggested that submergence ratios in the range of 4-5:1 should be combined with a Q_G:Q_L less than two to assure energy efficiency in aquaculture operations. Wurts et al. (1994) conducted hydraulic studies for individual and combined 7.6, 10.2 and 15.2 cm (3, 4, and 6 inch) air-lift pipes

submerged 100%. His results showed that maximum flow in various air-lift pipes was dependent on the amount of air injected. He concluded that as air flow and pipe diameter increased, water flow rates will also increase until the optimum air flow rate is achieved.

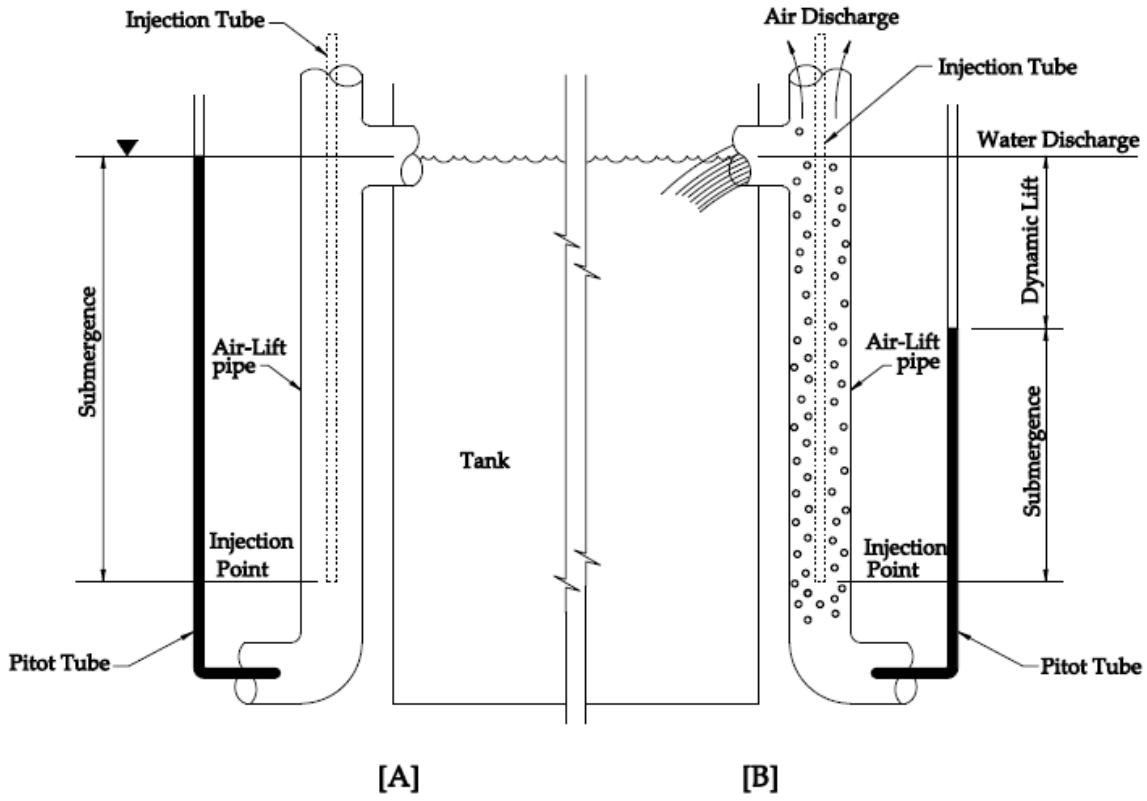


Figure 2-1. A common air-lift pump in stagnant [A] and operational [B] mode when water discharge is set at tank water level.

Both studies corresponding with injection depths of 50, 65, and 80 cm, he saw optimal Q_G:Q_L ratios of 2.6, 1.5, and 1.1 for a 15.2 cm pipe, with the 10.2 cm pipe resulting in optimal ratios of 2.0, 1.3, and 1.0. Parker and Suttle (1987) measured water flow rates in air-lift pumps ranging from 3.75 to 30 cm in diameter (1.5 to 11.8 inches). They concluded that an increase in the vertical lift height had a greater effect on water flow rates in larger diameter pipes compared to smaller pipes. As air flow increased logarithmically, the resulting water flow

increased linearly. Many others (Hird et al, 2000; Spotte, 1970; and Castro and Zielinski, 1980) have found similar results for air and water delivery rates.

Within the unique RAS environment, Loyless and Malone (1998) express the need to balance CO_2 removal and O_2 supply. Aeration studies are more widely available to the Aquaculturist, as the air-lift was not typically used for degasification. With only a small amount of research on CO_2 stripping, the ability for comparison is scarce. Colt and Orwicz (1991) along with Boyd (1990) looked at an assortment of subsurface aeration devices, comparing their standard aeration efficiencies (SAE). Experimenting with air-lift pumps, static and zero head tubes, diffusers, and aspirators; Colt and Orwicz claimed an air-lift an efficient tool, cited standard aeration efficiencies (SAE) between 2.0 – 2.1 kg O_2 kw^{-1} hr^{-1}. Loyless and Malone (1998) performed various RAS air-lift experiments with 5.08 cm (2") riser pipes, defining the standard oxygen and carbon dioxide transfer rates, SOTR and SCTR, as a function of gas input. They were able to show that even small changes in dynamic or static lift could greatly affect the gas transfer performance of an air-lift. They reported that aeration and degasification rates increased with air flow while SAE and degasification efficiency decreased. Based on the transfer kinetics, they concluded the aeration requirements would control the air-lift design assuming minimum dissolved oxygen of 6 mg l^{-1} and a maximum dissolved carbon dioxide of 5 mg l^{-1} for a given set of operating conditions; 30°C system stocked at 0.5 lb gal^{-1} and fed at 3% day^{-1}.

METHODOLOGY

Figure 2-2 represents the air-lifted PolyGeyser® unit at HSWRI. The system is cored around a 160 m^3 fiberglass holding tank (approximately 42,000 gallons). The tank, not shown, is complemented with a 0.708 m^3 (25 ft^3) PolyGeyser® unit, [A], along with dual 20.3 cm (8 inch) air-lifts, [B]. Due to setup constraints, however, all tests were evaluated across a single 20.3 cm air-lift. On top of the

air-lift lies a 20.3 cm 'T' with perpendicularly attached 90° elbows for water discharge. The center line of the 'T' was positioned at the tank water level, i.e. static lift was set at zero. The dynamic headlosses associated with this system were complexed by parallel operation of a bottom center drain and a surface drain system that fed into a sump (containing a large, fine-mesh, egg capturing net) that rejoined the flows prior to passing though the PolyGeyser®. During normal operations the flow through the dual airlift system ranged from 766 and 1,277 l min^{-1} while total lift varied between 32.6 and 48.8 cm. Corresponding with Q_G:Q_L recommendations, air input ranged between 45 to 80 ft^3 min^{-1}. Paquette et al (2009* in press) provides a detailed description of the system and operational setup at HSWRI.

A 2.54 cm (1") PVC injection pipe, [C], was set 152 cm (60") below the tank water level, in anticipation of the high dynamic headlosses. The dynamic losses were measured across the system through a series of pitot tubes. Following procedures outlined by Loyless and Malone (1998), submergence and total lift (equivalent to dynamic lift here) were measured relative to water elevation observed in the pitot tube positioned at the base of the airlift draft tube. The tip of the pitot tube was set parallel to the draft tube side wall, in effect neglecting the velocity component.

Air was supplied from a 3 phase, 2 hp Sweetwater blower and measured with an in-line variable area Rotameter from King Instruments, model 7205-0221. Liquid flow was measured with a GF Signet model 2537 paddlewheel meter and validated with a calibrated bucket and stopwatch. HQ40d Dual-Input Multi-Parameter Digital Meters were utilized for DO, pH, pressure, and temperature readings. Other measurements during experimentation included salinity, alkalinity, and lift height along with submergence depths. It should be noted alkalinity resided near 115 mg l^{-1} $CaCO_3$ throughout experimentation.

Temperature varied between 19 and 20°C, with an overall average near 19.5°C, and salinity remained 33 ppt throughout experimentation.

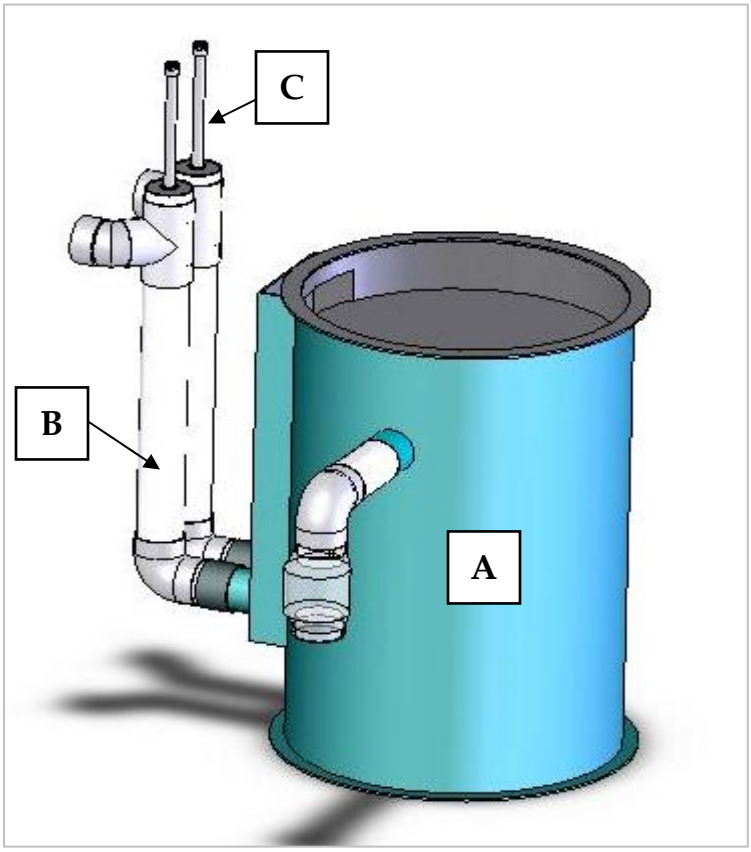


Figure 2-2. 20.3 cm air-lifts complementing the 0.7 m³ PolyGeyser® at HSWRI.

Hydraulic Behavior

The hydraulic assessment of the air-lift unit was performed as a series of focused studies. Each study related the amount of gas input, Q_G, and the resulting water flow, Q_L, as previously defined for multiple lift heights. Three air inputs were chosen to be evaluated; 850, 1,132, and 1,415 l min^{-1}, (30, 40, and 50 ft^3 min^{-1}, respectively). The air delivery rate was held constant and water flow was measured as the head loss for the system was artificially increased/decreased by manipulation of a ball valve on the approach pipe. The process was repeated for each gas input and the resulting head loss measurements. Each hydraulic performance test was conducted in triplicate and

the following table summarizes the results obtained. The lift to submergence ratios, resulting flows, and Q_G: Q_L ratios are represented.

Table 2-1. Average hydraulic behavior for a 20.3 cm air-lift operating at multiple lift heights in a warmwater marine RAS.

L [cm]	% L	Q_G [l min^{-1}]	Q_L [l min^{-1}]	Q_G:Q_L
30.5	20%	850	908	0.94
38.1	25%	850	755	1.12
		1,132	979	1.16
		1,415	1,117	1.27
45.7	30%	850	623	1.36
		1,132	757	1.50
		1,415	923	1.53
		1,699	1,122	1.51
		1,840	1,197	1.54

The tests conducted at 1,699 and 1,840 l min^{-1} (60 and 65 ft^3 min^{-1}) of air under 45.7 cm lift were utilized for the hydraulic results section only. Hydraulic summaries can be found in Appendix A.

Gas Transfer

The theory and methods presented by Loyless and Malone (1998) and Johnson (2008) were followed for the gas transfer experiments. Under the selected operational conditions, aeration and degasification trials occurring from pre to post-air-lift were examined. Dual probes were used to measure the inlet and outlet pH/DO readings, DO for aeration and pH for degasification. For either study, the author determined the top, or outflow, of the PolyGeyser® the most appropriate location for inlet air-lift readings (refer back to Figure 2-2). The outlet readings were measured through an outlet port previously tapped into the underside of the outlet 'T'. A flexible piece of tubing connected to the outlet port allowed continuous fluid flow into a 1 liter beaker where probe measurements

were recorded. The fluid retention time in the tubing was considered diminutive to overall flow rate and was therefore neglected for simultaneous measurements. The outlet probe was positioned at the bottom of the 1 liter beaker to prevent any interference in readings from bubble entrapment in the probe. Each gas transfer experiment was performed in duplicate.

Aeration Trials

The meters, attached with dual luminescent DO probes, were first calibrated following the manufacturer's recommendations. The meters were set to record simultaneous measurements at predetermined time intervals. The probes were then placed in test water bath and allowed to equilibrate until similar readings were obtained. Finally, the probes were moved to their respective inlet and outlet positions for recording. The dissolved oxygen levels were then altered by purging pure nitrogen gas, a means of oxygen depletion in an aqueous environment, into the egg collection sump. The nitrogen gas was introduced from a compressed cylinder attached to fine port diffusers. Protecting the broodstock with a direct line of supplemental oxygen, the nitrogen gas was discharged until a predetermined dissolved oxygen concentration was achieved at the inlet. The nitrogen purge was then shut off and readings were taken until they were reasonably close to those that began the trial.

The oxygen transfer rate, OTR, was determined from multiplying the liquid flow by the difference in inlet and outlet concentration, as seen in Eq. 2-1.

$$OTR = \left(C_{out} - C_{t} \right) * Q_{L} * 60 * 24 * 10^{-6} \qquad \textbf{Eq. 2-1}$$

OTR (kg O_2 day^{-1}) describes the oxygen uptake occurring at each recorded point. C_t is the oxygen concentration seen at the inlet (pre air-lift) and C_{out} denotes the outlet (post air-lift) concentration, both in mg l^{-1}. Q_L (l min^{-1}) was estimated by the average of several measurements during the experimentation. A set of plots portraying the concentration deficit, $C_{deficit}$ determined by C_s-C_t where C_s is

saturation concentration, versus the oxygen uptake rate were then analyzed. Due to the influence of the pure oxygen bleed into the holding tank, the DO concentration at the beginning of each test was assumed to be the apparent oxygen saturation concentration, denoted as C_s' (mg l^{-1}). Linear trend lines were derived under an assumption of zero intercept (Figure 2-3). The resulting slope represents an OTR coefficient for $C_{deficit}$, ultimately relating OTR with its particular deficit concentration.

The graph represents one particular aeration study performed at 1,415 l min^{-1} of air for two various lifts, 38.1 and 45.7 cm. The oxygen transfer coefficients were drawn and their relationship with the rate of air input was examined. An additional linear regression was utilized plotting air flow versus the OTR coefficient and the resulting trend line produced a second slope coefficient, arbitrarily defined as $K_{O_2}^{20.3}$. This value allowed the actual oxygen transfer rate, AOTR, to be calculated as seen in Eq. 2-3.

$$AOTR = K_{O_2}^{20.3} * \left(C_s^{'} - C_t \right) * Q_G \qquad \textbf{Eq. 2-3}$$

AOTR is represented in units of kg O_2 day^{-1}. Q_G is once again air flow in l min^{-1} and C_s' and C_t are previously defined concentrations in units of mg l^{-1}. Average OTR coefficients and K values, along with experimental data collected for each aeration trial can be found in Appendix A.

Degasification Trials

The second set of experiments conducted consisted of CO_2 stripping tests. The same meters were utilized for recording but pH probes replaced the DO probes. They were calibrated to within a 92-102% slope using 4, 7, and 11 buffer solutions. Alkalinity of the test water was measured in triplicate by potentiometric titration similar to the methods referenced in EPA method 310.1 and ASTM method 2320B.

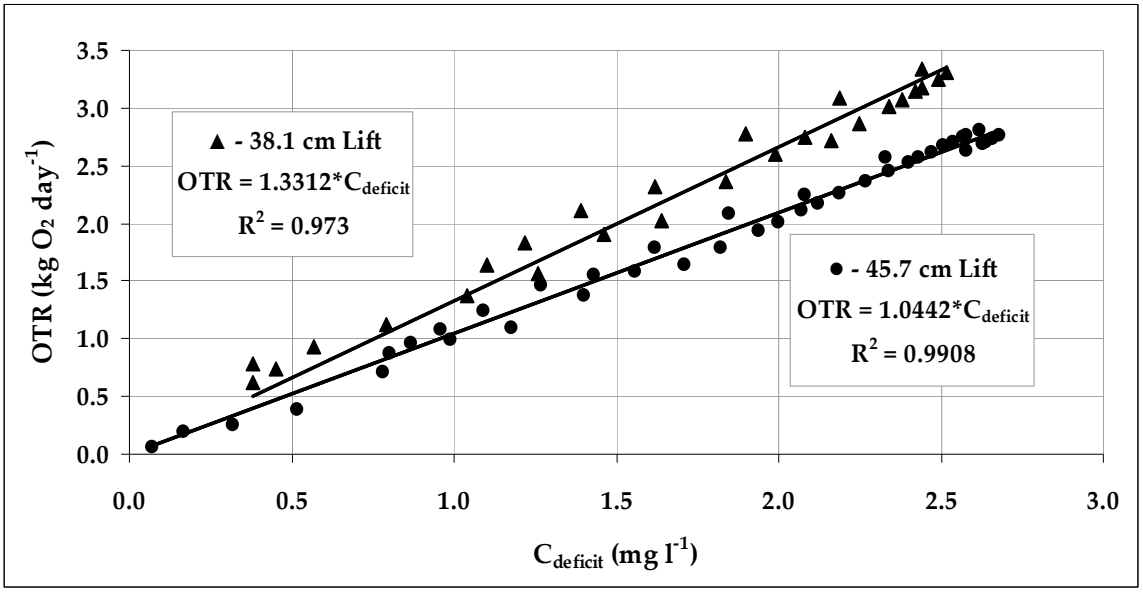


Figure 2-3. Plot of concentration deficit versus oxygen transfer rate at 1415 l min^{-1} of air. 1,135 & 890 l min^{-1} of liquid flow was produced for 38.1 & 45.7 cm lift, respectively.

The probes were allowed to equilibrate and then placed in their inlet or outlet position. Carbon dioxide gas replaced the nitrogen gas as it provoked a moderated rise in CO_2, as evidenced by a decrease in pH. The purge was cut off when the desirable pH was evident and readings were taken until pH levels reached measurements near those that began the trial. The pH and DO were continuously monitored in the holding tank for safety purposes. The large tank volume masked the influence of the short term perturbations of the gas balance.

The carbon dioxide concentration was determined upon the carbonate seawater equilibrium equations. Water held CO_2 cannot be distinguished from carbonic acid, yet kinetics show that over 99% of dissolved carbon dioxide exist strictly as CO_2. This method assumes the carbon dioxide concentration is strictly in the form of CO_2. It was also assumed bicarbonate ions control alkalinity over the tested pH range in saline waters. Eq. 2-4 was followed to calculate the carbon dioxide concentration for seawater. Methods and derivations were adapted from

Dickson and Millero (1987), Dickson et al. (2007), Kilho (1969), and Zeebe and Gladrow (2001).

$$CO_2 = \left[\left(\frac{Alk * \left[H^+ \right]^2}{K_1 * \left(\left[H^+ \right] + 2 K_2 \right)} \right) * 44.01 * \frac{\rho_{sw}}{1000} \right] * 1000 \qquad \textbf{Eq. 2-4}$$

CO_2 is the resulting dissolved carbon dioxide concentration in mg l^{-1}, Alk is the measured alkalinity of seawater in units of μmol/kg, $[H^+]$ is 10^{-pH}, and K_1 and K_2 are the first and second acid dissociation constants derived from equations found in Appendix A from Lueker et al. (2000). The dissociation constants were based on temperature and salinity, in units Kelvin and ppt respectively. The formula weight of carbon dioxide is noted as 44.01 g mol^{-1} and the density of seawater at test temperature, p_{sw} in kg m^{-3}, was based on adaptations from Schetz and Fuhs (1999).

The deficit role for the degasification process was then reversed, portraying a lower saturation concentration and determined by C_t-C_s. The carbonate buffer system exists in salt water as it does in fresh water, yet only more effective with the presence of the excess base. For research purposes, however, the same assumptions were adapted from Loyless and Malone (1998) and Eshchar (2003), assuming C_s to be constant at 0.5 mg l^{-1}. The CTR represents the kg CO_2 day^{-1} that occurs at the specified deficit and liquid flow.

$$CTR = \left(C_t - C_{out} \right) * Q_L * 60 * 24 * 10^{-6} \qquad \textbf{Eq. 2-5}$$

C_t and C_{out} are once again the inlet and outlet concentrations, only now as mg CO_2 l^{-1}. A linear regression of CTR versus deficit produced this time a carbon dioxide transfer coefficient, CTR coefficient for $C_{deficit}$. Figure 2-4 shows an example plot used to derive these coefficients, similar to Figure 2-3 for oxygen kinetics.

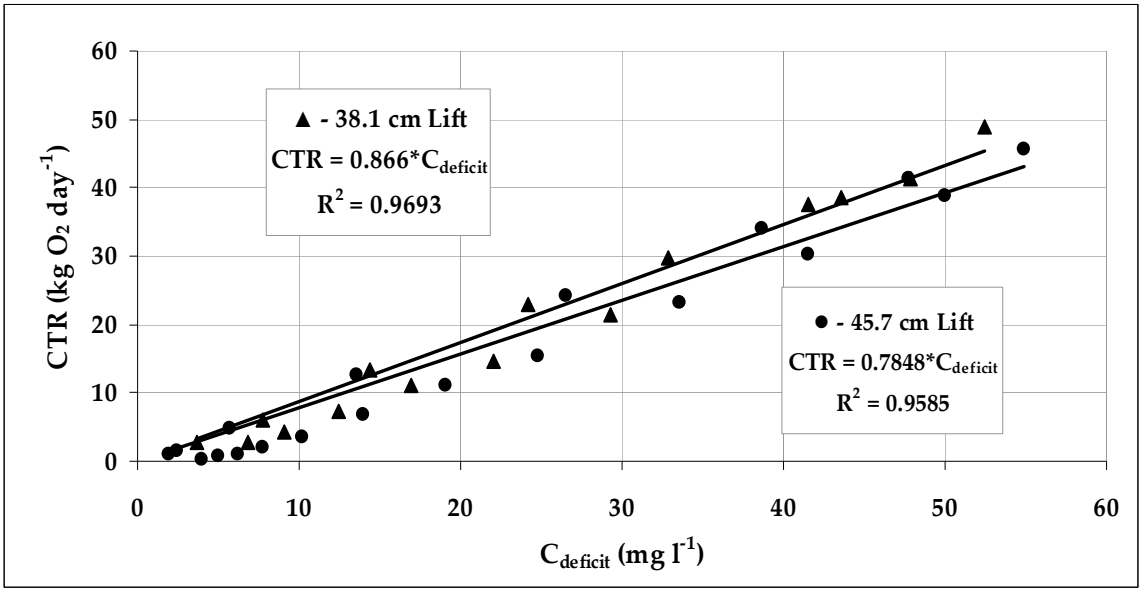


Figure 2-4. Plot of CTR versus a given concentration deficit at 1415 l min^{-1} of air based on 38.1 & 45.7 cm lift, respectively.

The transfer coefficients were plotted against their corresponding gas inputs and a secondary linear regression was implemented. The resulting coefficient, noted as $K_{CO_2}^{20.3}$, allowed the determination of ACTR, the actual carbon transfer rate as seen in Eq. 2-6.

$$ACTR = K_{CO_2}^{20.3} * (C_t - C_s) * Q_g \qquad \textbf{Eq. 2-6}$$

ACTR is characterized with units of kg CO_2 day^{-1}, concentrations in mg l^{-1} and air input in l min^{-1}. Average CTR coefficients and K values, along with experimental data collected for each degassing trial can also be found in Appendix A.

RESULTS AND DISCUSSION

Numerous studies have developed experiential and theoretical equations for predicting air-lift characteristics based on various parameters (Todoroki et al., 1973; Reinemann, 1987; Castro and Zielinski, 1980; Loyless and Malone, 1998). Therefore, when predicting the water delivery with oxygen and carbon dioxide transfer, the authors deem the results are significant to the specific parameters tested and are only an estimation of the gas transfer kinetics. The first set of

experiments display hydraulic relationships for certain air-lift parameters; including Q_G, Q_L, lift height, and submergence. The second and third set of experiments utilized the hydraulic parameters to perform aeration and degasification studies in order to obtain oxygen and carbon dioxide transfer rates.

The hydraulic analysis showed that liquid flow increased linearly with respect to gas input, shown in Figure 2-5. Most air-lift fluid delivery tests are represented with logarithmic fits, as their studies allowed gas test values to approach levels nearing zero. In this lower range of air flows, water delivery drops off dramatically. The constraints of testing on a loaded RAS applied, however, and such values were not attempted. Therefore, a linear fit was most applicable. An additional test was performed at 849.4 l min^{-1} air under 30.5 cm (12 inch) of lift and resulted in an average liquid flow of 900 l min^{-1}. This test was not plotted under hydraulic analysis, but was utilized for all gas transfer tests.

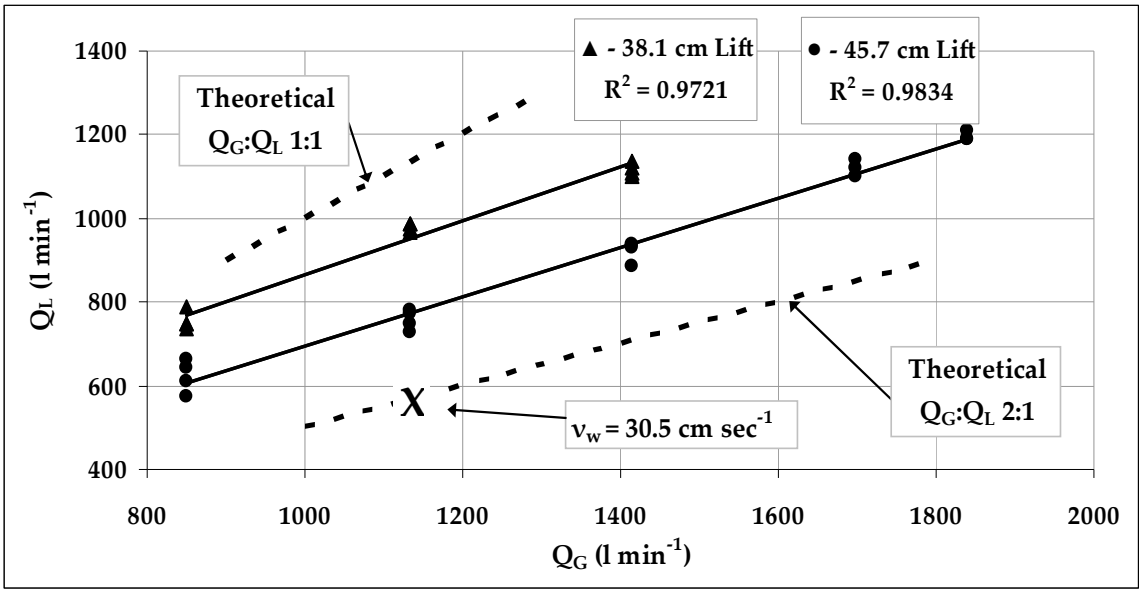


Figure 2-5. Gas versus liquid flow at lift heights of 38.1 and 45.7 cm for a 20.3 cm air-lift.

The linear fit is validated across the range of gas inputs tested, with resulting water flows for separate lift heights. Comparing with similar gas

inputs, higher liquid flows are seen for smaller lift heights, as expected; i.e. as lift to submergence ratios decrease, the ensuing water discharge increased. Empirical equations for predicting water flow were established.

$$Q_L = 0.6386 * Q_G + 227.03 \quad \textbf{Eq. 2-7}$$

[L = 38.1 cm, Q_G = 850 – 1,415 l min^{-1}, Q_L = 735 – 1,135 l min^{-1}]

$$Q_L = 0.5896 * Q_G + 105.31 \quad \textbf{Eq. 2-8}$$

[L = 45.7 cm, Q_G = 850 – 1,840 l min^{-1}, Q_L = 575 – 1,210 l min^{-1}]

Eq. 2-7 & 2-8 are limited to the noted conditions. Q_L and Q_G are represented as l min^{-1} of water and gas, respectively, while L denotes lift height in cm. The recommendations from Malone and Gudipati (2005b) were easily maintained within Q_G:Q_L ratios of 1:1 and 2:1. The water velocity design point for a 20.3 cm air-lift, X, is noted at approximately 568 l min^{-1} water flow (30.5 cm sec^{-1} velocity) and a corresponding 1,132 l min^{-1} air (Q_G:Q_L of 2:1). Since this design air injection rate yields water flows greater than the 2:1 operating line, the safety factors from Malone and Gudipati (2005b) are further conveyed. For example, in a condition of 45.7 cm of lift in a 20.3 cm air-lift pipe, the graph potentially demonstrates that an air injection of approximately 800 l min^{-1} would achieve the 30.5 cm sec^{-1} velocity recommendation, reducing energy requirements.

The actual aeration and degasification kinetics for the 20.3 cm air-lift are ultimately related to the relationships found in Figure 2-6. The oxygen and carbon dioxide kinetic behavior is drawn from the applied linear regressions. The graph supports well regressed trends, r-squared values typically greater than 0.90, portraying OTR and CTR coefficient for $C_{deficit}$ versus air injection for given lift heights. As shown, the coefficient for $C_{deficit}$ increases linearly with air injection for both studies, consequently increasing AOTR & ACTR. The operating zone portrays the typical air injection range seen for 20.3 cm air-lift systems.

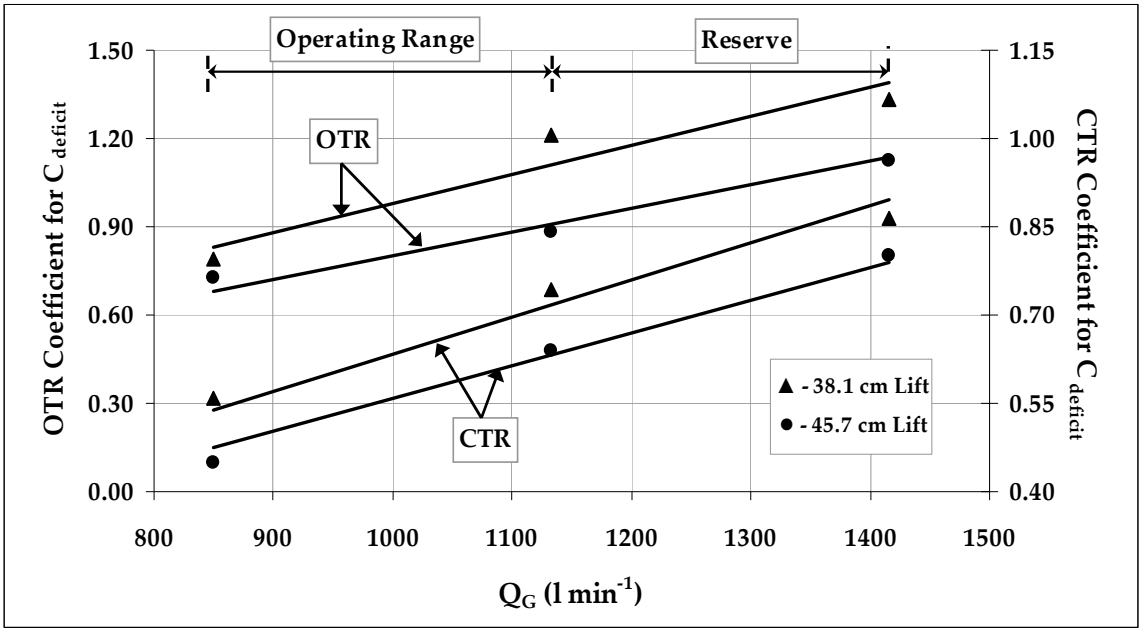


Figure 2-6. Correlation between air input and CTR and OTR coefficients for $C_{deficit}$ for a 20.3 cm air-lift at 38.1 and 45.7 cm lift heights.

Everything beyond is noted as a reserve, or the attainable range for this air-lift. Extrapolations are not recommended beyond the air flow regime, as linear representations are not expected. Table 2-2 shows the developed relationships between gas input and concentration deficit and the resulting K terms for AOTR and ACTR.

Table 2-2. Gas transfer equations and operating limits for a 20.3 cm air-lift in a 33ppt marine environment.

L	Q_G	Q_L	AOTR	ACTR
[cm]	[l min^{-1}]	[l min^{-1}]	[kg O_2 day^{-1}]	[kg CO_2 day^{-1}]
30.5	850	908	0.00114 Q_G (C_s-C_t)	0.00069 Q_G (C_t-C_s)
38.1	850 - 1,415	755 - 1,117	0.00098 Q_G (C_s-C_t)	0.00063 Q_G (C_t-C_s)
45.7	850 - 1,415	623 - 923	0.00080 Q_G (C_s-C_t)	0.00056 Q_G (C_t-C_s)

The transfer coefficients show modest resilience to varying lift heights, increasing slightly as lift decreases. With no statistically significant difference between the various lift heights, a combined regression equation may be feasible. For comparison purposes, however, the equations were independently

represented. The larger transfer coefficients can be correlated with an elevated residence time in the draft pipe column, i.e. lower lift heights result in a longer vertical water column. This lowered lift height increases submergence, increasing the air/water contact time, allowing for supplemental transfer.

Though aeration trials present higher transfer coefficients, the authors suggest gas transfer is oxygen limited; i.e. carbon dioxide transfer will surpass the oxygen transfer. This is mainly contributed to the presumption that larger deficits are typically seen for carbon dioxide. In normal seawater at 20°C oxygen saturation is set at 7.60 mg l^{-1} (Timmons et al., 2001) whereas CO_2 can be presumably defined at 0.5 mg l^{-1}, as mentioned earlier. Water quality recommendations were also provided for typical aquaculture settings; > 5 mg l^{-1} DO, < 60 mg l^{-1} CO_2 for tolerant species (i.e. tilapia), and < 20 mg l^{-1} CO_2 for sensitive species (i.e. salmonids). Therefore, even for sensitive species, the degree of concentration deficit is clearly observed. Applied to a typical air-lifted marine RAS (assuming 33 ppt salinity, alkalinity of 115 mg l^{-1}, 20°C, and target concentrations of 5 mg l^{-1} O_2 and 20 mg l^{-1} CO_2) a 20.3 cm air-lift operating under 850 l min^{-1} air injection and 45.7 cm lift will concurrently aerate and degasify 1.77 kg O_2 day^{-1} and 9.28 kg CO_2 day^{-1}, respectively. If conditions became extreme, i.e. 3 mg l^{-1} O_2 and 60-80 mg l^{-1} CO_2 suggested by Wheaton (1977), transfer rates are seen at 3.13 kg O_2 day^{-1} and 28.32 kg CO_2 day^{-1} for a measured 3 mg l^{-1} O_2 and CO_2 of 60 mg l^{-1}. Based on the results, gas transfer in air-lifts is oxygen limited. If the water is sufficiently aerated to sustain fish systems via air-lift, the system water in turn will be adequately degasified.

CONCLUSION

Analysis shows that air-lift performance is consistently dependent on certain variables; i.e. lift height, submergence, and air flow. The data consists of specific results, pertinent to the applied operational parameters. The developed

hydraulic, AOTR, and ACTR results further enhance the continually improving design matrix of the air-lift, supplying partial guidelines for a 20.3 cm air-lift in a marine environment. Transfer kinetics for O_2 and CO_2 were well described through linear relationships as a simple pseudo-second order correlation was adequate for the author's engineering objectives. As the optimization of air-lifted PolyGeysers® are further developed, the economic viability for efficiently and successively operating a RAS increases. Additional gas exchange studies are suggested to accommodate a broader variety of air-lifted applications.

CHAPTER 3: OXYGEN AND CARBON DIOXIDE GAS TRANSFER CHARACTERISTICS FOR CONCURRENTLY INJECTED AIR-LIFTS IN FRESHWATER RECIRCULATION UNITS

INTRODUCTION

Recirculating aquaculture systems (RAS) have evolved from traditional flow through systems as pertinent solutions for water availability, disease management, and environmental impacts. The continuous water circulation and extensive water treatment have prevented them from becoming more commercially accepted. Therefore, simpler and more efficient designs are essential for associated costs and energy reduction. Air-lifts contribute to the fundamental recirculation processes of water movement, oxygen delivery, and carbon dioxide removal providing engineers an opportunity for process consolidation.

An alternative to the more common centrifugal pump, the air-lift mechanism provides a simpler, more compact, and energy efficient device for low-head water circulation (Spotte, 1970). Timmons et al. (2001) state air-lifts move the highest volume of water per unit of energy. Cost efficiencies are increased compared to centrifugal pumps as operation and maintenance costs are lowered due to the absence of moving parts and minimal required technical expertise. Additionally, Reinemann (1987) provided studies that show energy consumption for recirculating and aerating a low-head system is approximately one-third the cost of a conventional pumped system.

Interim design criteria for air-lifted floating bead filter combinations were well established in 2005, and provided specific guidelines to facilitate air-lift usage for the experimental setups. The objectives were to quantify and evaluate gas exchange characteristics for concurrently injected 10.2, 15.2, and 20.3 cm air-lifts in low-head, non-loaded, freshwater recirculation systems.

BACKGROUND

Air-lift pumps consist of a partially submerged piece of pipe fitted with an air injection received at some location near the bottom (Wheaton, 1977). Once the design variables are understood, they are easily constructed from readily available PVC piping supplied with air from regenerative blowers, reducing capital and operational costs. Air is injected dropping the density of the air/water mixture. The higher inlet pressure at the bottom of the pipe forces the less dense air/water mixture upward and out of the air-lift. A complete overview of air-lift technology can be found in Nicklin (1963), Timmons et al. (2001), and many others. Figure 3-1 shows a typical sketch of a siphoning U-tube air-lift pump (SUTA). The theory and operation of the SUTA pump are similar to those of the basic air-lift, differing only in that the approach pipe usually draws effluent water from a pressurized filtration device, creating a siphoning phenomenon.

An air-lift that discharges above a water source has a slightly more complex operation than one discharging at the source. The vertical distance between the air injection point and tank water level is referred to as injection depth. In representation [A], when air-lift is non-operational, the injection depth is equal to submergence, and is best noted as the driving force or pressure available that fuels the air-lift. The vertical distance above the water level to the resulting discharge is static lift, and represents total lift (L). The submergence to lift ratio (S:L) defines the optimum operating height an air-lift performs under. As gas enters the injection tube, the lift height is now broken into two components, as dynamic headlosses accompany static lift in representation [B]. Dynamic lift represents frictional losses incurred after exiting the tank (pipe fittings, filter, etc…), and is usually measured through a series of pitot tubes, which are easily tapped into PVC pipes and measured on a vertically connected board with adjoining ruler devices. Generally, pitot tubes are constructed from

flexible clear tubing and established at critical points throughout the recirculating system.

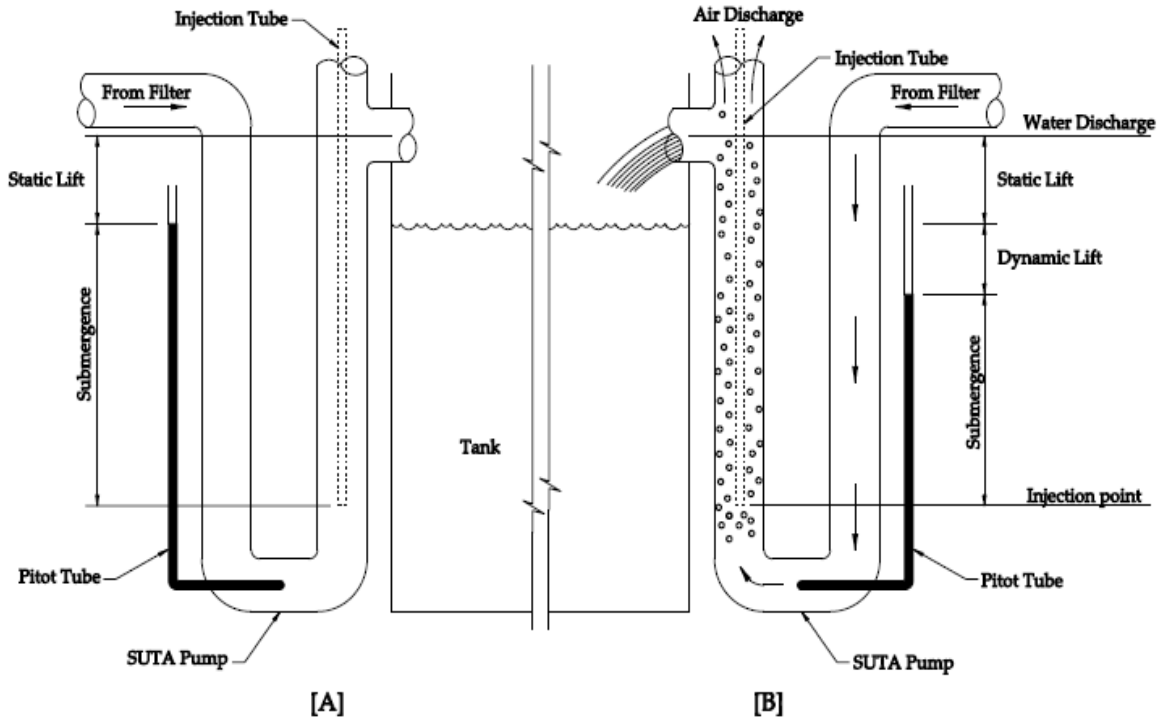


Figure 3-1. Common description of a SUTA pump defining terms for stagnant [A] and operational [B] mode when water discharge is set above tank water level.

Gas to liquid ratios (Q_G:Q_L) refer to volumetric air injection and the ensuing liquid flow, and help determine the level of efficiency a pump operates under. As air injection (Q_G) exponentially increases, the resulting fluid discharge (Q_L) will linearly increase until some optimal or peak air injection is met, at which water flow will slowly decline (Wurts et al, 1994; Castro and Zielinski, 1980; Todoroki et al., 1973; Parker and Suttle, 1987; and Reinemann et al, 2001). Castro and Zielinski (1980) used S:L ratio alongside length and diameter of pipe to predict maximum liquid flow for a specific air injection. Others, Gudipati (2005), Johnson (2008), and Loyless and Malone (1998), developed discharge equations based on varying air injections and submergence ratios for a single pipe. Injection devices are also key components to air-lift operation. The use of

air-stones significantly enhances gas transfer, but as noted in Parker and Suttle (1987), several centimeters of line back pressure can greatly reduce air-lift performance. Open-ended air injection devices allow water flow to be maximized as compared to air stones, and are usually the selection of choice for air-lifts (Loyless and Malone, 1998; Reinemann and Timmons, 1989).

Dissolved oxygen is most often the limiting factor to aquaculture facilities, and thus appropriately receives a lot of attention in any facility design effort. However, with increasing density levels and feed loadings, CO_2 management has become critical to a successful unit. There are numerous aeration and degassing devices are available to recirculation units, but most are economically unpopular due to large capital and maintenance investments.

Reinemann and Timmons (1989) provided an equation to predict an oxygen transfer coefficient from Reynolds number; Re. Independent of the system volume, the prediction is based on the riser pipe volume alone with the conclusion that the coefficient was indifferent to wastes in the water, initial bubble size, or flow pattern. Tyler et. al (2006) showed aeration kinetics for three 10.2 cm air-lifts in partial recirculation and aeration systems (PRAS) as part of a raceway flow through system. They were able to obtain 0.081 kg O_2 hr^{-1} under 284 l min^{-1} (75 gal min^{-1}) liquid flow. Furthermore, the PRAS maintained discharge oxygen levels above 5 mg l^{-1} for 2.15 and 2.61 lb ft^{-3} biomass density and a feeding rate of 1.7%. Loyless and Malone (1998) determined standard oxygen transfer rate (SOTR) equations for 5.08 cm (2″) air-lifts. They cited SOTR values from 0.01 to 0.04 kg O_2 hr^{-1} through 28 to 142 l min^{-1} air. They concluded that aeration rates increased as gas input increased, while stating the tested air-lifts transferred oxygen 1/5 to 1/2 the rate of open water aeration systems. Johnson (2008) presented actual oxygen transfer rates (AOTR) in a 15.2 cm (6″) air-lift for wastewater treatment in a PolyGeyser® bio-filter. An equation was

presented to predict AOTR over 425 – 850 l min^{-1} (15 – 30 ft^3 min^{-1}) air injection. He concluded the air-lift was capable of supplying 1.5 kg O_2 day^{-1} at 425 l min^{-1} air and 3 mg l^{-1} DO, the minimal concentration required in the media bed before oxygen limitations occur.

Loyless and Malone (1998) furthered their research, determining standard carbon dioxide transfer rate (SCTR) equations for 5.08 cm air-lifts. They saw SCTR rates from 0.3 to 1.4 g CO_2 hr^{-1} in similar conditions to their SOTR work. They concluded degasification increased as gas input increased. Their steady state analysis concluded carbon dioxide concentration had a tendency to decrease as a constant air injection was proportional spread to an increasing number of air-lifts, while oxygen levels remained unchanged. Feed rate adjustment was shown to have a particular impact on the carbon stripping rates through the air-lift configuration. Their same analysis showed it would take 62 ft^3 air min^{-1} for 15 air-lifts (at a 3% feed rate) to reach a dissolved CO_2 concentration of 4 mg l^{-1}, whereas only 22 ft^3 air min^{-1} was required at a 1.5% feed. While the availability of degasification performance data is far more limited than aeration for air-lift pumps, information supports that air-injection methods utilizing gas to liquid ratios are viable carbon dioxide removal devices. Although not directly related to air-lifts, the principle for using gas to liquid proportionalities was adopted in this study. Piedrahita and Grace (1991) performed studies for predicting carbon dioxide transfer coefficients for a packed column utilizing Pall rings, and concluded that carbon mass transfer increased significantly with gas to liquid ratio and only decreased slightly with alkalinity. Others, such as Aitchison (1999) and Eschchar et al. (2003), conducted studies on CO_2 removal rates via surface aeration and concluded air injection had significant effects on carbon dioxide removal rates.

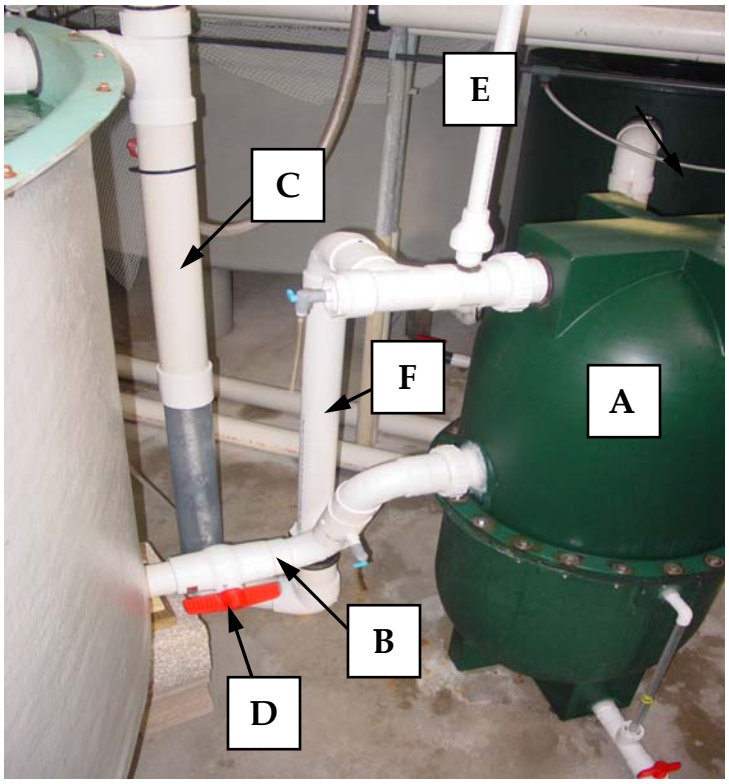
METHODOLOGY

Experiments were performed at USDA research facility Harbor Branch Oceanographic Institute (HBOI). 3-m diameter tanks (1.2-m depth, volume approximately 7.8 m^3) previously installed for rearing studies were used for experimentation. The tanks were complemented with PolyGeyser® bio-filters (see Figure 3-1) followed by SUTA (siphoning u-tube air-lift) pumps for circulation and gas exchange. However, the filters chambers were free of media since experiments were performed on non-loaded systems.

Figure 3-2. PolyGeyser® floating bead filter used in air-lift studies (picture taken from Bellelo, 2006).

Three schedule 40 PVC SUTA pumps were studied; 10.2, 15.2 and 20.3 cm in diameter. The air injection pipe was set approximately 152 cm (60") below the water level. Air was supplied from a 3-phase Sweetwater S-63 2.5 hp regenerative blower and was directly measured with Cole-Parmer direct read polysulfone in-line air flow meters; model no. R-32470-05 for 1-12 scfm and model no. R-32470-06 for 4-48 scfm. Water flow was measured in triplicate with a calibrated bucket and stopwatch.

The actual SUTA/filter combination tested during experimentation can be seen in Figure 3-3, with [A] displaying the PolyGeyser®. The approach pipe, [B], draws water from the tank and feeds into the filter. [C] and [F] resemble the SUTA, and are discussed more thoroughly later. The corresponding legend displays the relevant identification letters and their label descriptions.



SUTA/PolyGeyser® Legend

A. PolyGeyser® filter
B. Approach pipe
C. SUTA lift pipe
D. Ball valve
E. Backflush pressure release pipe
F. SUTA siphon pipe

Figure 3-3. The 10.2 cm air-lift/bio-filter configuration unit used for gas exchange experiments and legend displaying pertinent labels.

Basic criteria were followed for the experimental protocol. The approach pipe, [B], was sized targeting a minimum water velocity of 0.61 m sec^{-1} (2 ft sec^{-1}), to prevent solids from settling (Ricketts et al., 2004; Timmons et al., 2001; and Malone and Gudipati, 2005b). The lift portion of the SUTA, [C], followed an assumed water velocity of 0.30 m sec^{-1} (1 ft sec^{-1}), also adapted from Malone and Gudipati (2005b), equating to 151, 341 and 568 l min^{-1} for each diameter pipe, respectively. In addition, maximum lifts were assumed to be less than 15 inches to assure that all runs would have S:L ratios no less than 3:1, or no greater than 33% lift to submergence. To mimic these lift requirements, along with headlosses typically seen in PolyGeyser® filters, S:L ratios were controlled by artificial manipulation of the ball valve, [D], located on the approach pipe. Dynamic lift was measured with pitot tubes, one installed in tank and the other just prior to air injection. Static lift was simply measured with a calibrated tape measure from

tank water level to air-lift discharge point. For representation purposes, [E] is the backflush pressure release line with check valve that assures re-establishment of siphoning action in the beginning SUTA pipe [F].

The operating parameters summary for the hydraulic studies can be seen in Table 3-1. Liquid and gas flow, SUTA pipe size, L:S, and Q_G:Q_L values are presented as each analysis was performed in triplicate. The outlet drain below the tank was limited to 10.2 cm (4 inch) along with a max blown air volume of 580.4 l min^{-1} (21 ft^3 min^{-1}). As a result, the max attainable water flow in the 20.3 cm study was 495.1 l min^{-1} (131 gal min^{-1}), slightly lower than the 568 l min^{-1} sought after. Hydraulic summaries can be found in Appendix B.

Table 3-1. Hydraulic performance summary for 10.2, 15.2, and 20.3 cm air-lifts and resulting gas to liquid ratios.

Air-lift dia. [cm]	Q_G [l min^{-1}]	Q_L [l min^{-1}]	L [cm]	% L	Q_G:Q_L
10.2	169.9	163.5	30.5	20%	1.0
15.2	339.7	341.4	30.5	20%	1.0
	495.5	338.4	38.1	25%	1.5
20.3	580.4	495.1	30.0	22%	1.2

Each gas transfer experiment was conducted on an individual setup, i.e. degasification studies were performed in separate air-lift/tank units to prevent interference from the chemicals used in the aeration studies, and vice versa. Ample time was permitted in between studies for equilibrium to reestablish in the test water. Triplicates were performed for each experiment and meters were calibrated accordingly before each trial. Temperature varied between 25 and 28°C, dependent upon experimentation. Salinity and alkalinity averaged near 1 ppt and 155 mg $CaCO_3$ l^{-1}, but salinity was neglected during calculations as such low levels resemble freshwater conditions.

Aeration Studies

Method

Aeration studies measurements were taken with separate Hach HQ10 DO meters for dissolved oxygen, temperature, and pressure readings. Measurements were taken at inlet and outlet air-lift positions to observe the oxygen mass transfer occurring at a single time. The DO probes were calibrated following the manufacturer's recommendations. Inlet readings were taken near the bottom drain of the tank while outlet measurements were recorded at a certain position downstream of the discharge that would prevent bubble interference from the discharge water. The position was completely dependent on air injection and the resulting water flow from the air-lift. The higher the air injection and water flow, the further downstream the probe was placed. The meters were programmed for simultaneous measurements at predetermined time intervals and allowed to equilibrate before experimentation, to within 1%. The air-lift was then shut off, and following ASCE Standard 2-91 (1992), 650 grams of Anhydrous Sodium Sulfite catalyst along with 1.3 grams of Cobalt (II) Chloride were added to deoxygenate the test water near 0 mg l^{-1}, and readings taken until 90% saturation.

Data Analysis

Dissolved oxygen measurements were taken directly from the meters as mg l^{-1} of DO. A linear regression analysis was used to calculate the transfer coefficients for oxygen transfer. First, the mass transfer rates were determined for each measurement time step. The difference in the inlet and outlet concentration was multiplied by the average liquid flow resulting in an oxygen transfer rate, OTR in kg O_2 day^{-1}.

$$OTR = \left(C_{out} - C_t \right) * Q_L * 60 * 24 * 10^{-6} \qquad \textbf{Eq. 3-1}$$

C_t and C_{out} represent inlet and outlet oxygen concentration, mg l^{-1}; and Q_L is water discharge in l min^{-1}. The transfer rates were plotted against the deficit concentration, $C_{deficit\_O2}$ in mg l^{-1}, as described through equation 3-2:

$$C_{deficit\_O_2} = C_s - C_t \qquad \textbf{Eq. 3-2}$$

where C_s represents DO saturation concentration at test temperature in mg l^{-1}. DO saturation was interpolated based on freshwater and test temperature. A linear trend was used under zero intercept assumption. The resulting slope coefficient was termed OTR coefficient for $C_{deficit}$. The coefficients were averaged and correlated with gas input to develop equations for predicting oxygen transfer rates as a function of concentration deficit and air injection input.

From the plot, there seems to be greater oxygen transfer potential as air injection increases for the same size pipe, i.e. as the 15.2 cm study increased from a 1:1 Q_G:Q_L to 1.5:1. There is a larger differential between the two 15.2 cm regression lines than, for example, as pipe size increased from 10.2 to 15.2 cm, both gas to liquid ratios of 1:1.

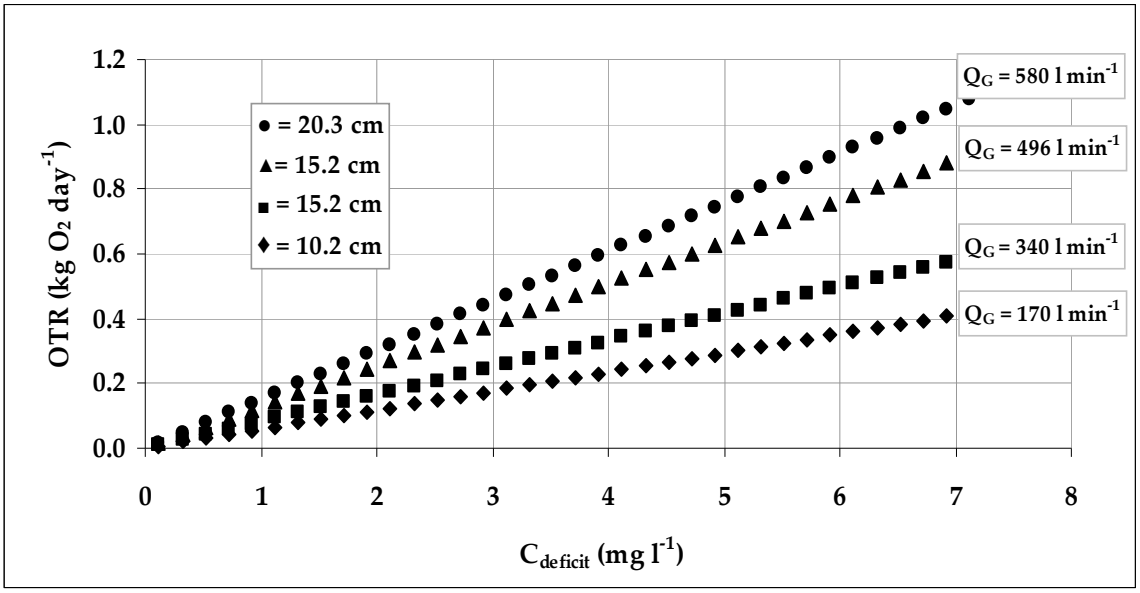


Figure 3-4. Oxygen transfer rate summary plot for each tested air-lift. OTR is seen to increase with deficit, air injection, and pipe diameter.

However, the argument can be made there is a much larger differential between the 1:1 10.2 cm study and the 1.5:1 15.2 cm study. Nevertheless, no conclusions were drawn on these assumptions as the data may seem biased, as it was the only study that analyzed two or more air injections. The resulting OTR equations are presented in Table 3-2 as based on lift height, gas to liquid flow, pipe size, and concentration deficit.

Table 3-2. Oxygen transfer rate summary and operating parameters for the tested air-lifts in non-loaded freshwater RAS units.

Air-lift dia.		Lift	Q_G	OTR
[cm]	Q_G:Q_L	[cm]	[l min^{-1}]	[kg O_2 day^{-1}]
10.2	1:1	30.5	169.9	0.058 (C_s-C_t)
15.2	1:1	30.5	339.7	0.083 (C_s-C_t)
15.2	1.5:1	38.1	495.5	0.127 (C_s-C_t)
20.3	1.2:1	30.0	580.4	0.152 (C_s-C_t)

The standard oxygen transfer rate (SOTR) was determined next for each set of air-lift data. The calculations were adapted from the ASCE standard method for measurement of oxygen transfer in clean water (ASCE, 1992). A linear regression was performed to predict the gas transfer coefficients from the formulas in Eq. 3-3 (Boyd and Watten, 1993; Colt and Orwicz, 1991). The coefficients were obtained for both inlet and outlet readings.

$$-\ln\frac{(C_s - C_t)}{(C_s - C_o)} = K_L a_{O_2} * t \qquad \textbf{Eq. 3-3}$$

C_s is calculated identical to the method used above. The data outside the 20 and 90% range of saturation were truncated to eliminate residual error. C_o and C_t represent initial and temporal concentration, respectively. K_La values, represented as min^{-1}, were taken for both inlet and outlet readings with no significant difference in values. Therefore, the values were averaged and corrected for temperature with the use of Arrhenius's relationship in Eq. 3-4.

$$(K_L a_{O_2})_{20} = (K_L a_{O_2})_T * (\Theta)^{(20-T)} \quad \textbf{Eq. 3-4}$$

Where $(K_L a_{O2})_{20}$ represents the oxygen transfer coefficient at 20°C, $(K_L a_{O2})_T$ represents the coefficient at test temperature T, and Θ is arbitrarily defined as 1.024. With the corrected $K_L a$ values, the SOTR was determined as kg O_2 hr^{-1}.

$$SOTR = (K_L a_{O_2})_{20^\circ C} * (C_{s,20^\circ C} - C_m) * V * 60 * 10^{-6} \quad \textbf{Eq. 3-5}$$

$C_{s,20°C}$ represents the saturation concentration in water at 20°C, 9.07 mg l^{-1} for O_2. V is volume of water in liters and C_m is defined as standard measured concentration, representing 0 mg l^{-1} as O_2 (Loyless and Malone, 1998). Experimental data, average $C_{deficit}$ coefficients and equations, and $K_L a_{20}$ and SOTR values can be found in Appendix B.

Degasification Studies

pH/Alkalinity Method

Alkalinity and pH measurements were used to calculate the carbon dioxide concentration from procedures outlined in Loyless and Malone (1998). Total and phenolphthalein alkalinity were measured with digital titration according to HACH test method 8203. The method is valid for ranges in between 10 to 4,000 mg $CaCO_3$ l^{-1}, and average alkalinity values were near 155 mg l^{-1} throughout experimentation. An HQ40d Dual-Input Multi-Parameter Digital Meter was utilized for pH, temperature, and pressure readings. Separate readings were taken at inlet and outlet position for similar reasons outlined in the aeration studies. The probes were first calibrated using 4, 7, and 11 buffer solutions, and then placed at similar positions to those in the aeration tests. Pure carbon dioxide was purged into the tank water through fine port diffusers until the depressed pH target was achieved. Continuous pH recordings were taken at predetermined time intervals until the authors observed system recovery.

pH/Alkalinity Data Analysis

CO_2 calculations for the pH/alkalinity tests were performed as followed. Eq. 3-6 was used to calculate the concentration of carbon dioxide as mg l^{-1} (Loyless and Malone, 1998).

$$CO_2 = \frac{(10^{-pH})*(Alk)*(44,000)}{(4.3*10^{-7})*(50,000)} \quad \textbf{Eq. 3-6}$$

The molecular weight of CO_2 is 44,000 mg $mole^{-1}$ and there is 50,000 mg $CaCO_3$ in one equivalent. The equilibrium reaction constant is noted as $4.3*10^{-7}$ at 25°C. Alk represents the form of alkalinity (bicarbonate, carbonate, or hydroxide) in mg $CaCO_3$ l^{-1}. The phenolphthalein indicator equaled zero during all experiments, concluding total alkalinity was strictly in the form of bicarbonate alkalinity.

Methods similar to the oxygen transfer calculations were then followed. The carbon transfer rate, CTR, was first calculated by multiplying the CO_2 inlet/outlet concentration differentials by the liquid flow in Eq. 3-7.

$$CTR = (C_t - C_{out})*Q_L*60*24*10^{-6} \quad \textbf{Eq. 3-7}$$

All variables remain constant with OTR calculations except concentration terms, now represented as mg CO_2 l^{-1}. A linear regression plotted CTR versus concentration deficit, with deficit reversed as seen in Eq. 3-8.

$$C_{deficit\_CO_2} = C_t - C_s \quad \textbf{Eq. 3-8}$$

C_s represents CO_2 saturation concentration and assumed to be 0.5 mg l^{-1} in all instances (Loyless and Malone, 1998). Figure 3-5 represents the studies plotting CTR versus deficit concentration to obtain the resulting slope coefficient termed CTR coefficient for $C_{deficit}$. The graph shows CTR increased with air input, pipe diameter, and concentration deficit, as predicted.

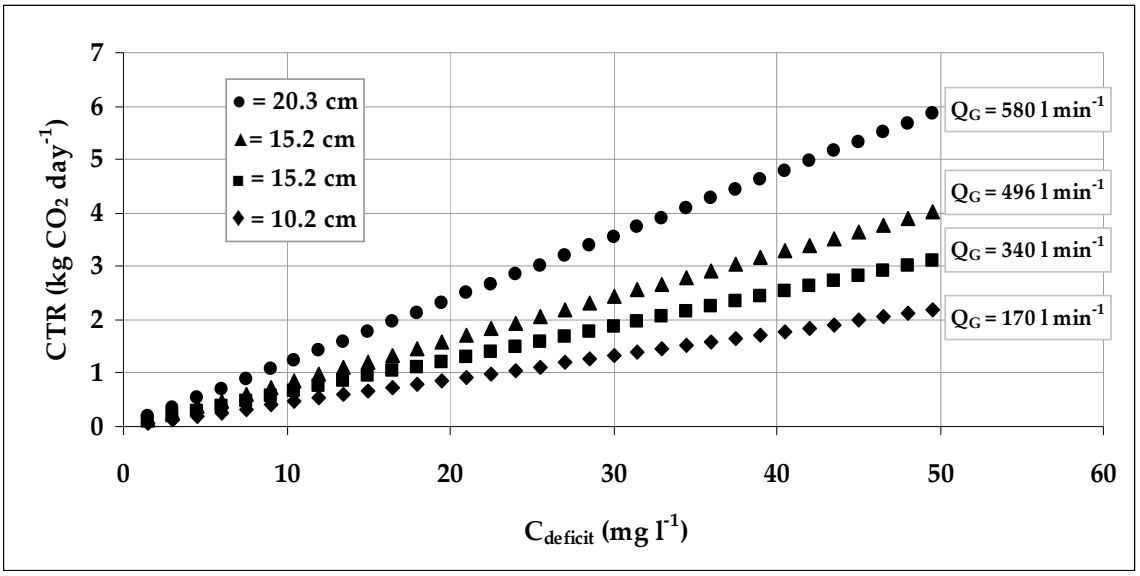


Figure 3-5. Carbon transfer rate summary plot for each tested air-lift. CTR is seen to increase with deficit, air injection, and pipe diameter.

Contradictory to OTR conclusions, gas input seems to have a lesser effect on CTR than pipe diameter, as shown again in the 15.2 cm case study. But as concluded, no major assumptions were established. The resulting slope coefficients were developed into carbon transfer equations for a given deficit in Table 3-3.

Table 3-3. Carbon transfer rate summary and operating parameters for the tested air-lifts in non-loaded freshwater RAS units.

Air-lift dia.		Lift	Q_G	CTR
[cm]	Q_G:Q_L	[cm]	[l min^{-1}]	[kg CO_2 day^{-1}]
10.2	1:1	30.5	169.9	0.044 (C_t-C_s)
15.2	1:1	30.5	339.7	0.062 (C_t-C_s)
15.2	1.5:1	38.1	495.5	0.081 (C_t-C_s)
20.3	1.2:1	30.0	580.4	0.119 (C_t-C_s)

The standard carbon transfer rate (SCTR) was then determined similar to SOTR calculations and methods found in Loyless and Malone (1998). A linear regression was performed to predict K_LaCO_2 for both inlet and outlet readings through Eq. 3-9.

$$-\ln\frac{(C_t - C_s)}{(C_o - C_s)} = K_L a_{CO_2} * t \qquad \textbf{Eq. 3-9}$$

C_o and C_t are initial and temporal concentration, and C_s followed previous assumptions. Data outside the 20 and 90% range were eliminated. The K_La values for inlet and outlet readings were averaged as there were no significant differences in the two. The coefficients were then corrected for temperature through Eq. 3-4 and SCTR was determined in Eq. 3-10 as kg CO_2 hr^{-1}.

$$SCTR = (K_L a_{CO_2})_{20^\circ C} * (C_m - C_{s,20^\circ C}) * V * 60 * 10^{-6} \qquad \textbf{Eq. 3-10}$$

$C_{s,20°C}$ represents the saturation concentration in water at 20°C, 0.5 mg CO_2 l^{-1}. V is water volume in liters and C_m is standard measured concentration, 1 mg CO_2 l^{-1} (Loyless and Malone, 1998). Experimental data, average $C_{deficit}$ coefficients and equations, and K_La_{20} and SCTR values can be found in Appendix B.

Head Space Reactor Method

An additional experiment for estimating the CO_2 stripping capability for each air-lift configuration was evaluated, utilizing a head space reactor for measuring CO_2. Watten et al. (2004) outline a feasibility technique of measuring dissolved carbon dioxide through head space partial pressures. The head space reactor, Figure 3-6, was positioned on a cat walk centered across the top of the tank for in tank CO_2 measurements. Only one reading was recorded for this study, taken from the bottom center of the tank similar to the pH or DO inlet position in the previous studies. The water supply line into the reactor consisted of flexible tubing fed from an in-tank sump pump. Flow rate into the reactor followed recommendations in Watten et al. (2004). A portable CO_2/O_2 Gas Analyzer from CEA Instruments was used to measure the head space gas composition as percent CO_2. Purging methods and time measurements closely followed those in the pH/Alkalinity experiments.

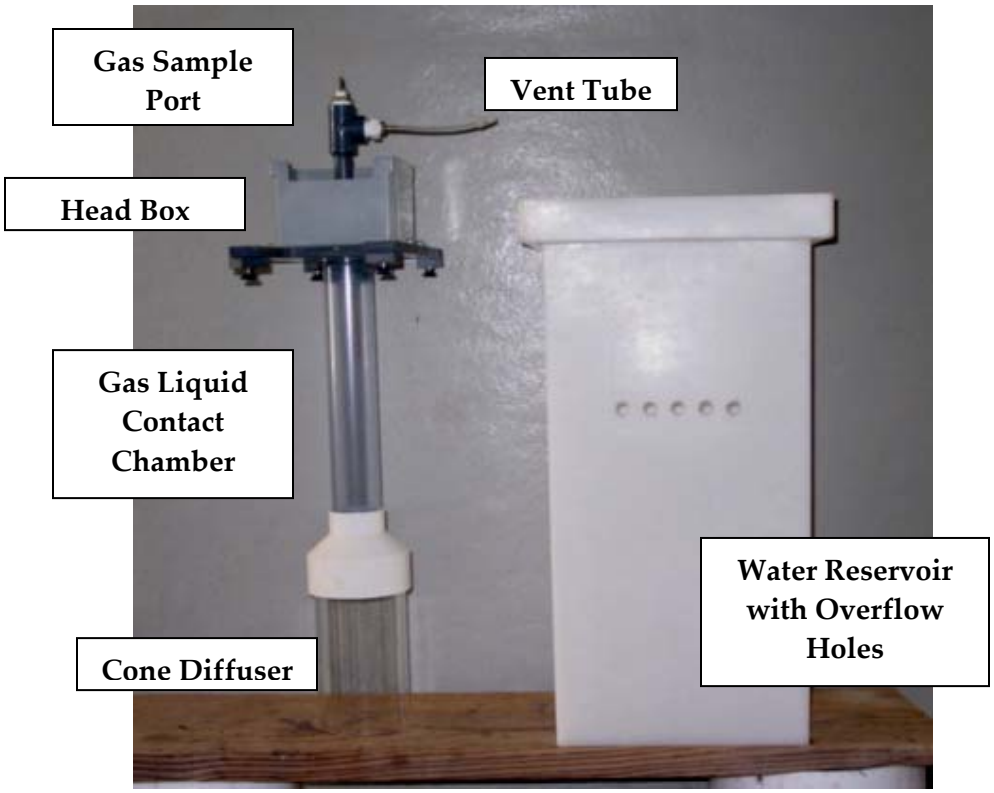


Figure 3-6. Head space reactor used for in-tank measurements of carbon dioxide.

This method was performed to compare SCTR rates to the pH/Alkalinity method only, and therefore an in-depth analysis was not performed as to which method was better suited for calculating aqueous CO_2 concentrations.

Head Space Reactor Data Analysis

The dissolved carbon dioxide concentration was calculated from the method found in Colt (1984) as a function of temperature, salinity and pressure. The dissolved carbon dioxide, DCO_2, was found through Eq. 3-11.

$$DCO_2 = B_{CO_2} * \frac{P^G CO_2}{0.3845} * 1.041 \qquad \textbf{Eq. 3-11}$$

where B_{CO2} is the Bunsen solubility coefficient value for CO_2 based on temperature and salinity and 1.041 includes the multiplication factor for gas monitor calibration. P^GCO_2 is the partial gas pressure of carbon dioxide and determined through:

$$P^{G}CO_2 = BP * \frac{\%\,CO_2}{100} \qquad \textbf{Eq. 3-12}$$

where BP is barometric pressure in mm Hg and % CO_2 is the reading taken from the gas analyzer. Linear regressions were again used and Eq. 3-9 was utilized to determine K_La_{CO2} followed with Eq. 3-10 to determine SCTR in kg CO_2 hr^{-1}. All assumptions used for the pH/alkalinity study stayed constant. Head space experimental data and transfer rates can be found in Appendix B.

RESULTS

Aeration Results

Particular emphasis has been given to gas transfer estimations related to the use of various sized air-lifts. The first set of analysis displays aeration kinetics under typical air-lifted PolyGeyser® operating conditions. The SOTR was based on the transfer rate from near 0 mg O_2 l^{-1} up to near saturation. Table 3-4 summarizes SOTR values for the 10.2, 15.2, and 20.3 cm air-lift studies.

K_La values were well represented through linear regressions, resulting in r^2 values above 0.99. As shown, oxygen transfer increased with pipe diameter and gas input, resulting in rates from 0.0594 kg O_2 hr^{-1} for the 10.2 cm air-lift up to 0.2073 kg O_2 hr^{-1} for the 20.3 cm setup. SOTR increased 155% from the 10.2 to 15.2 cm (both 1:1) test, 6% in between the two 15.2 cm tests, and 37% from the 15.2 cm (1:1) to the 20.3 cm (1.2:1).

Table 3-4. SOTR and K_La summary for the gas transfer aeration tests.

	Air-lift dia. [cm]			
Parameter	**10.2**	**15.2**	**15.2**	**20.3**
Q_G:Q_L Ratio	1:1	1:1	1.5:1	1.2:1
Q_G [l min^{-1}]	169.9	339.7	495.5	580.4
Q_L [l min^{-1}]	163.5	341.4	338.4	495.1
Kinetics				
$K_La_{O2,\,20}$ [min^{-1}]	0.0151	0.0348	0.0370	0.0451
SOTR [kg O_2 hr^{-1}]	0.0594	0.1516	0.1605	0.2073

Based on the 1:1 tests only, with the 20.3 cm trial closely related for comparison, it seems oxygen transfer is significantly affected with certain air injection changes, and should level out or begin to decline at some optimal air injection.

The results show larger rates than those presented in Loyless and Malone (1998) primarily due to the larger lift pipes and greater air injections tested in these experiments. For comparison at similar air injections, they reported 0.042 kg O_2 hr^{-1} for approximately 170 l min^{-1} air in a 5.08 cm air-lift, whereas the above results show a slightly larger SOTR of 0.059 kg O_2 hr^{-1} for a 10.2 cm air-lift. Their operating parameters, however, exceeded the 0.30 m sec^{-1} water velocity target and the 1:1 to 2:1 Q_G:Q_L range sought after in this study. The oxygen transfer results further exemplify the air-lift as a beneficial aeration device.

Degasification Results

SCTR values were evaluated as concentrations nearing 100 mg CO_2 l^{-1} were reduced lower than 10 mg l^{-1}. Table 3-5 presents average K_La and SCTR values for each degasification evaluation, pH/Alkalinity and head space reactor. The degasification results showed smaller K_La and SCTR values than those in the aeration rates. The pH/Alkalinity trials produced rates from 0.0013 to 0.0057 kg CO_2 hr^{-1}, while head space trials produced 0.0025 to 0.0061 kg CO_2 hr^{-1}. The initial presumption is that the head space reactor, method b, produced larger transfer coefficients and SCTR values than those calculated through pH/Alkalinity, method a. However, the variance between the two methods began to decrease as pipe size and air rate increased. The 10.2 cm study showed a differential of 0.0012 kg CO_2 hr^{-1} between method a and b, whereas the 20.3 cm study only differed by 0.004. The author felt an explanation could be pinned to the diverse and complex CO_2 calculations involved for each method, but no further investigations were performed as to which method was better suited.

Table 3-5. SCTR and K_La_{CO2} summary for the gas transfer degasification tests, including both pH/Alkalinity and head space methods.

	Air-lift dia. [cm]			
Parameter	**10.2**	**15.2**	**15.2**	**20.3**
Q_G:Q_L Ratio	1:1	1:1	1.5:1	1.2:1
Q_G [l min^{-1}]	169.9	339.7	495.5	580.4
Q_L [l min^{-1}]	163.5	341.4	338.4	495.1
Kinetics				
a) pH/Alkalinity method				
$K_La_{CO2,\ 20}$ [min^{-1}]	0.0062	0.0171	0.0185	0.0226
SCTR [kg CO_2 hr^{-1}]	0.0013	0.0041	0.0044	0.0057
b) Head Space method				
$K_La_{CO2,\ 20}$ [min^{-1}]	0.0113	0.0218	--	0.0281
SCTR [kg CO_2 hr^{-1}]	0.0025	0.0047	--	0.0061

Both show validity in their methodologies and results, but for discussion purposes, the pH/Alkalinity method was assumed as most applicable. Analogous to aeration results, carbon transfer rates increased with pipe size and air injection. R^2 values were once again well represented for K_La determination, above 0.98. The 15.2 cm study shows a small increased stripping capability as Q_G:Q_L went from 1:1 to 1.5:1, altering the required air flow from 339.7 l min^{-1} to 495.5 l min^{-1} along with a 5% increase in lift height. The SCTR (pH/Alkalinity method only) value increased 7.3%, whereas the change from the 10.2 to 15.2 cm air-lift (both 1:1 Q_G:Q_L) had a more dramatic effect on CO_2 removal, increasing SCTR almost 216%. However, only a 30% higher stripping change is noticed from the 1.5:1 15.2 cm air-lift trial to the 1.2:1 20.3 cm pipe. Based on these observations, it seems SCTR rates will begin to plateau at some predetermined air injection volume for each pipe size, with further studies needed for clarification.

Loyless and Malone (1998) presented SCTR values for a 5.08 cm air-lift near 0.0011 – 0.0013 kg CO_2 hr^{-1}, almost identical to the 10.2 cm study, both tested at 170 l min^{-1} air injection. It is peculiar why almost similar rates were obtained

for the different sized pipes, and justification may be related to the submergence depths and liquid flows along with their effect on the air/water contact time, controlling the in-situ gas exchange per pass in the air-lift. The liquid flow and submergence depth in Loyless and Malone (1998) was near 125 l min^{-1} and 91 cm, slightly lower than the 164 l min^{-1} and 122 cm tested. The permissible time for air/water contact per air-lift pass equated to approximately 1 second and 3.5 seconds for the 5.08 and 10.2 cm studies respectively. The close agreement between the SCTR values negates the fact that differences in residence times, liquid flows, and submergence alone have a substantial effect on the carbon stripping potential in an air-lift. For instance, the 15.2 cm (1:1 Q_G:Q_L) study observed a substantial 216% SCTR increase from the 10.2 cm test, but only at a slightly higher contact time per air-lift pass, 3.9 seconds. However, the 15.2 cm saw a much higher air injection volume, near 340 l air min^{-1}, and concludes that air injection itself controls the majority of degasification potential in an air-lift.

DISCUSSION

It is clearly evident that aeration and degasification rates are based on air injection, pipe size, and submergence and lift parameters. The kinetics from the standardized tests show considerable more time is required to aerate or degasify at lower airflows. With limited data sets, however, empirical relationships defining SOTR/SCTR were not developed for such defining variables as air injection.

Gas transfer becomes more difficult with increasing oxygen and decreasing carbon dioxide concentrations, decreasing OTR and CTR respectively. Masser et al. (1999) exclaim DO levels above 60% saturation or above 5 mg l^{-1} and carbon dioxide concentrations below 20 mg l^{-1} are required in most warmwater systems for optimal growth. Adapted with the results from Tables 3-2 and 3-3, a feasibility analysis was performed to help predict gas transfer and resulting

concentrations under the recommended operating conditions. Figure 3-7 plots C_t, either oxygen or carbon dioxide, versus the transfer rates for each air-lift configuration. This graph in particular shows the corresponding rates and concentrations for a target 5 mg O_2 l^{-1}.

In order to extrapolate the CO_2 concentrations, the axes for OTR and CTR were manipulated to characterize the molecular weight equilibriums between the two elements (1.38 moles CO_2 per mole O_2). Moving up the y-axis centered on 5 mg l^{-1}, arrows correlate the oxygen regression lines to the opposing carbon regression lines for each air-lift configuration, for example the 20.3 cm OTR regression line corresponds to the 20.3 cm CTR regression line, and etc.

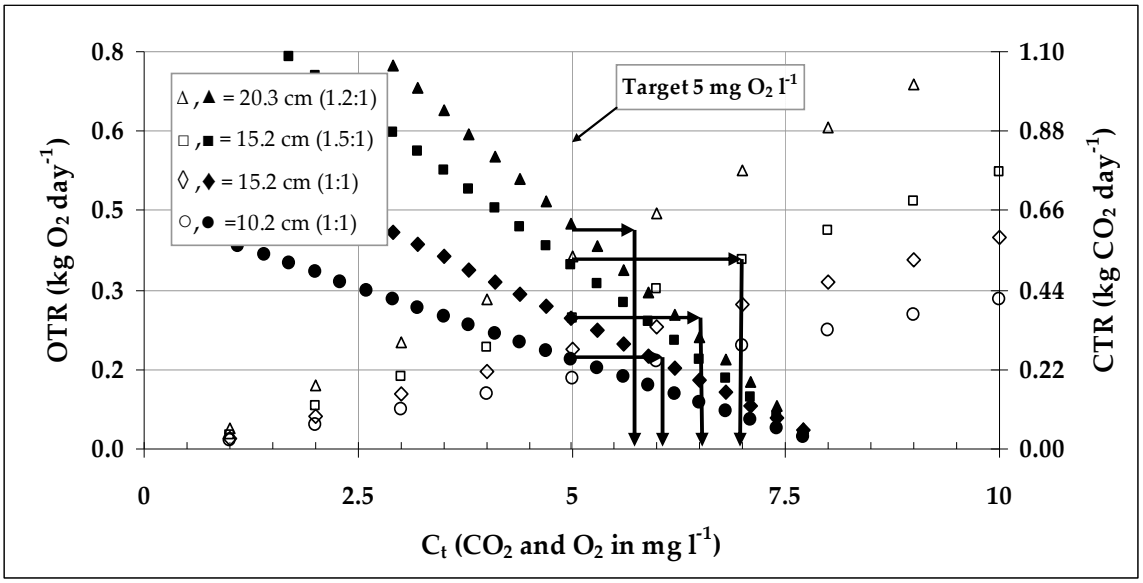


Figure 3-7. Resulting CO_2 concentrations in various air-lifts for a target DO of 5 mg l^{-1}. The shaded symbols represent OTR and the transparent symbols portray CTR.

A secondary arrow is drawn downward signifying the resulting C_t as the ensuing carbon dioxide concentration. Table 3-6 represents the transfer rates and carbon dioxide concentrations for each air-lift configuration targeting 5 mg O_2 l^{-1}. As shown, each configuration is capable of keeping CO_2 levels well below the recommended 20 mg l^{-1}; at 6.1, 6.6, 6.9, and 5.8 mg CO_2 l^{-1} respectively.

Table 3-6. OTR and CTR values along with resulting CO_2 concentrations based on a target 5 mg l^{-1} DO.

Air-lift Dia. [cm]	Q_G:Q_L	OTR [kg O_2 day^{-1}]	CTR [kg CO_2 day^{-1}]	Resulting CO_2 [mg l^{-1}]
10.2	1:1	0.181	0.246	6.1
15.2	1:1	0.262	0.378	6.6
15.2	1.5:1	0.370	0.518	6.9
20.3	1.2:1	0.453	0.631	5.8

A number of tables could depict how various target DO levels would affect each air-lift's ability to manage carbon dioxide. Higher target DO values, such as 6 mg l^{-1}, would result in decreased CO_2 concentration as shown in the above figure. Alternately, lowering O_2 standards would result in higher CO_2 values. Nevertheless, each air-lift provides ample stripping capabilities to keep CO_2 levels below the recommended 20 mg l^{-1}, assuming the target 5 mg DO l^{-1}.

Higher stripping rates are seen with elevated CO_2 levels, i.e. larger deficits. For oxygen transfer, increasing deficits or depressed O_2 levels support greater aeration rates. However, the degree of oxygen deficit is much smaller than that seen for CO_2, exhibiting oxygen limitations for engineered design efforts. Therefore, if sizing a particular air-lift for gas transfer alone, the results conclude CO_2 requirements will be met if designed for aeration capabilities alone.

CONCLUSION

The air-lift pump is both a simple and inexpensive device in terms of capital and maintenance costs. It promotes consolidation for key recirculation components, initial analysis indicating they can be used for water circulation, aeration, and degasification. Transfer rates, for oxygen and carbon dioxide, increased with both air injection and pipe diameter for 10.2, 15.2 and 20.3 cm air-lifts. Air-lifted units operating in Q_G:Q_L ranges of 1:1 to 1.5:1 show the ability to

maintain optimal water quality conditions. The approach is applicable to a wide variety of system types, not just air-lifts, yet the results are specifically relevant to the tested configurations, and no relationships are recognized for such alternate systems. Consideration should be given if designing air-lifts for oxygen or carbon dioxide requirements, as supplemental aeration or degasification may be needed. Further studies refining the gas exchange properties are needed to verify the appropriate scale at which these systems can operate.

CHAPTER 4: STEADY STATE ANALYSIS AND DISCUSSION

INTRODUCTION

This section analyzes the performance of a particular air-lift(s) in a broodstock, fingerling, and growout environment to determine if alternate forms of aeration or degasification are needed. A dissolved gas mass balance study (both O_2 and CO_2) was presented on an air-lifted Polygeyser® closed loop recirculation system shown in Figure 4-1. The purpose was to predict if air-lifts alone could prevent CO_2 or O_2 concentrations from surpassing recommended rules of thumb or guidelines for RAS applications, previously defined as >5 mg O_2 l^{-1} and <20 mg CO_2 l^{-1}. This particular arrangement has arrows indicative of positive transfer (analogous with a clockwise circle direction). The figure defines the tank and bio-filter as the two main control volumes across which the reaction rates, R, are determined.

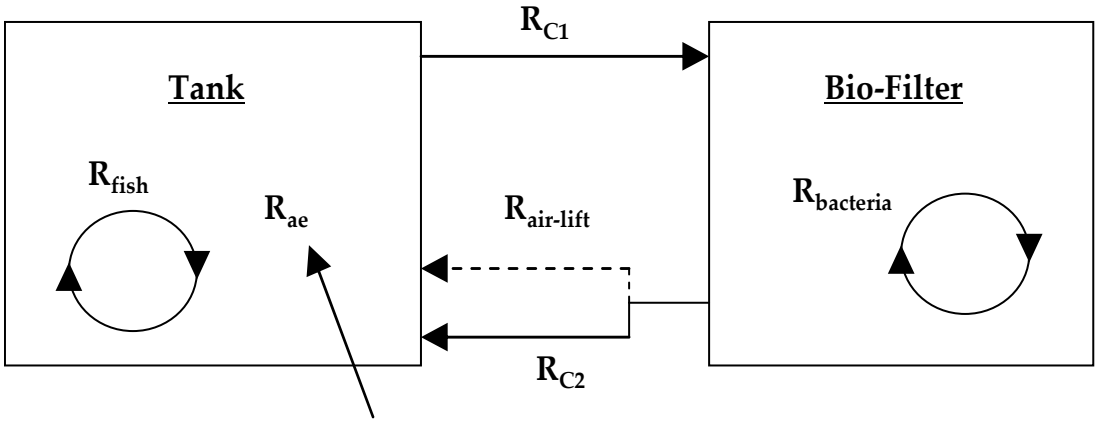


Figure 4-1. The general diagram for dissolved gas mass balance in an air-lifted PolyGeyser® recirculation system.

R_{C1} and R_{C2} are mass flux rates between tank and bio-filter, R_{fish} and $R_{bacteria}$ are transfer rates due to fish and bacteria respiration, respectively. Gas transfer delivery via air-lift is defined as $R_{air\text{-}lift}$; and although partially associated with R_{C2}, it was considered a separate reaction rate for this analysis. Boyd and Tucker (1998) define the gas transfer rate at the air/water interface, R_{ae} in this

case, of aquaculture ponds as the proportionalities of the gas partial pressure differentials between air and water, the water surface area, and water turbulence intensity, controlled mostly by wind speed. Since RAS systems are typically indoors, factors such as wind are unseen. Similar conditions, however, are sometimes encountered through rapid water circulation, creating turbulence similar to wind. Nevertheless, with such a small gas transfer capacity, atmospheric transfer was considered minimal and permitted R_{ae} to be neglected in this study (Boyd and Tucker (1998) cited carbon transfer rates at less than 0.0002 kg CO_2 m^{-2} day^{-1} for light to moderate winds, with similar O_2 results).

The rate of reactions terms and equation variables for determining C_{tank} and C_b, either oxygen or carbon dioxide, are found in Table 4-1. C_{tank} represents in-tank concentration while C_b represents effluent bio-filter concentration. The equations shown are descriptive, and do not yet portray negative or positive direction, as implemented later.

Table 4-1. The general equations for tank and bio-filter reaction rates as related to Figure 4-1.

Rate	Tank	Bio-filter
R_{C1}	$0.00144*Q_L*C_{tank}$	$0.00144*Q_L*C_{tank}$
R_{C2}	$0.00144*Q_L*C_b$	$0.00144*Q_L*C_b$
$R_{air\text{-}lift}$	$K_{air}*(C_{deficit})*Q_G$	
R_{fish}	$F*K_{fish}$	--
$R_{bacteria}$	--	$F*K_{bac}$

All rates were developed from the above equations and portrayed as kg constituent day^{-1}. F portrays the feed applied in kg day^{-1} and Q_G represents air injection rate in l min^{-1}. Q_L is liquid recirculation flow in l min^{-1} and related to the equations found in Chapter 2 as a function of Q_G. The unit conversion factor for R_{C1} and R_{C2} is 0.00144. K_{fish} and K_{bac} equal the fish and bacterial respiration coefficients, in kg constituent kg $feed^{-1}$. The carbon dioxide component of K_{fish}

and K_{bac} is related to the molecular equivalence between oxygen and CO_2, 1.38 moles CO_2 per mole O_2. $R_{air\text{-}lift}$ is based on the AOTR and ACTR relationships also taken from Chapter 2. The terms and units remain consistent, as $C_{deficit}$ and K_{air} are both constituent and parameter dependent. Oxygen deficit is found through (C_s-C_b) and carbon deficit with (C_b-C_s), both in mg constituent l^{-1}.

Since this analysis requests a single variable independent of time, it was assumed to follow steady state approximations, and validated through the fairly slow concentration changes typical in RAS operations. Equations and complete derivations for oxygen and carbon dioxide can be found in Appendix C.

OXYGEN BALANCE

When developing the oxygen concentration profile, separate mass balance equations were implemented for determining $C_{tank,O2}$ and $C_{b,O2}$, tank and bio-filter oxygen concentration. The equations followed the general diagram in Figure 4-1 and determined the following equations.

$$\frac{dC_{tank,O_2}V}{dt} = -R_{C1} - R_{fish} + R_{airlift} + R_{C2} \qquad \textbf{Eq. 4-1}$$

$$\frac{dC_{b,O_2}V}{dt} = R_{C1} - R_{bacteria} - R_{C2} \qquad \textbf{Eq. 4-2}$$

With the above equations and steady state conditions, Eqs. 4-3 and 4-4 were derived for the actual determination of $C_{tank,O2}$ and $C_{b,O2}$. Eq. 4-2 was first manipulated with the reaction equations from Table 4-1 to determine $C_{b,O2}$, and developed into Eq. 4-3.

$$C_{b,O_2} = C_{tank,O2} - \frac{F * K_{bac,O_2}}{0.00144\,Q_L} \qquad \textbf{Eq. 4-3}$$

Eq. 4-3 was then reverted back into Eq. 4-1 and $C_{tank,O2}$ was calculated through Eq. 4-4.

$$C_{\tan k,O_2} = -F\left(\frac{K_{bac,O_2} + K_{fish,O_2}}{K_{air,O_2} * Q_G} - \frac{K_{bac,O_2}}{0.00144\,Q_L}\right) + C_s \quad \textbf{Eq. 4-4}$$

CARBON DIOXIDE BALANCE

A carbon dioxide balance is fairly similar to the oxygen equations, with slight variations for certain rates. Following the same pattern in Figure 4-1, the carbon dioxide profile for the tank and bio-filter, $C_{tank,CO2}$ and $C_{b,CO2}$, are presented in Eq. 4-5 and 4-6.

$$\frac{dC_{\tan k,CO_2} V}{dt} = -R_{C1} + R_{fish} - R_{airlift} + R_{C2} \quad \textbf{Eq. 4-5}$$

$$\frac{dC_{b,CO_2} V}{dt} = R_{C1} + R_{bacteria} - R_{C2} \quad \textbf{Eq. 4-6}$$

Following steady state assumptions and equations from Table 4-1, $C_{b,CO2}$ and $C_{tank,CO2}$ were calculated through Eqs. 4-7 and 4-8.

$$C_{b,CO_2} = C_{\tan k} + \frac{F * K_{bac,CO_2}}{0.00144\,Q_L} \quad \textbf{Eq. 4-7}$$

$$C_{\tan k,CO_2} = F\left(\frac{K_{bac,CO_2} + K_{fish,CO_2}}{K_{air,CO_2} * Q_G} - \frac{K_{bac,CO_2}}{0.00144\,Q_L}\right) + C_s \quad \textbf{Eq. 4-8}$$

The solutions for both oxygen and carbon dioxide tank concentrations are verified in the following discussion section, and their respective relationships with air-lifts are presented.

SYSTEM ANALYSIS

Malone and Gudipati (2005b) developed interim guidelines for typical RAS units supporting air-lifted Polygeysers®, and these were adapted for the following system setups. This approach was controlled by feed load and air volumetric injection rates, with liquid flow dependent on Q_G. By following this method, elements such as system volume and biomass were not contributory to

the outcome and were considered negligible, and in doing so eliminated natural variability.

Some main assumptions were needed for consistency throughout each application analysis. Dual 20.3 cm air-lifts were recommended by Malone and Gudipati (2005b) for certain applications, but a single 20.3 cm air-lift was chosen for relation to the results from previous chapters. In conjunction with a 25 ft^3 PolyGeyser® bio-filter, the air-lift performed in a marine environment (~33 ppt). The air-lift was injected at 152 cm below the water source and set to discharge at 38.1 cm total lift. Temperature remained constant near 19.5°C and alkalinity was assumed to be approximately 115 mg $CaCO_3$ l^{-1}. The feed rates from Malone and Gudipati (2005b) were defined for broodstock, fingerlings, and growout applications as 4, 8.5, and 17 kg dry feed day^{-1}, respectively. Table 4-2 outlines the remaining coefficients and their relevant values.

Table 4-2. Air-lift K values along with fish and bacterial respiration K assumptions for oxygen and carbon dioxide chosen for the steady state analysis.

Parameter	O_2	CO_2	Units	Source
K_{air}	0.0098	0.00063	--	Table 2-2, 20.3 cm air-lift @ 38.1 cm lift
K_{bac}	*0.50	0.69	kg constituent kg^{-1} dry feed	*Timmons et al. (2001) nitrifiers and heterotrophs
K_{fish}	**0.35	0.48	kg constituent kg^{-1} dry feed	**Losordo and Hobbs (2000) range between 0.20 - 0.50

Note: CO_2 values for K_{bac} and K_{fish} = 1.38 * O_2 values.

It is the authors understanding that K values for fish and bacteria will vary depending upon fish age, species, backwash frequency in the bio-filter, media type, feeding periods, etc… However, as this analysis was specifically centered toward oxygen and carbon dioxide response to air-lifts, the same average values were adopted for each application. Also, K_{bac} was set toward the

higher end of bacterial respiration rates due to the enhanced nitrification (EN) media that was assumed to comprise the media bed in the PolyGeyser®.

Warmwater Marine Broodstock Evaluation at F = 4 kg day^{-1}

Using the broodstock feed loading of 4 kg day^{-1}, mass balance equations 4-4 and 4-8 were utilized in Figure 4-2 to predict tank oxygen and carbon dioxide concentrations as air injections ranged from 850 l min^{-1} to 2,250 l min^{-1}. The tested boundary limits adapted from Eq. 2-6 are portrayed as solid lines for O_2, CO_2, and Q_L, representing 850 – 1,415 l min^{-1} air injection. Extrapolations were not recommended beyond these limits, but for academic purposes a theoretical gas range (1,415 – 2,250 l min^{-1} or the ongoing dotted lines) was included to portray the Malone and Gudipati (2005b) design Q_G, 2,124 l min^{-1}. It should be noted their recommendation was strictly developed for facilitation of air-lift usage, and also provided supplemental air recommendations for in-tank aeration.

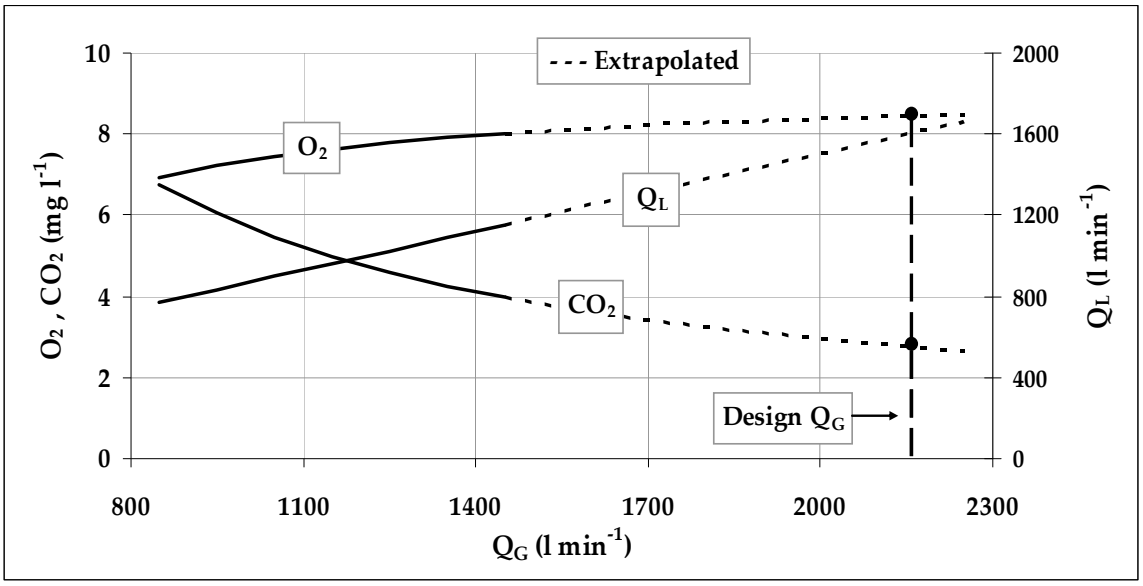


Figure 4-2. Resulting O_2 and CO_2 profiles along with water delivery rates for a broodstock environment (F = 4 kg day^{-1}) employing a 20.3 cm air-lift over a particular range of gas flows.

As air injection increases along with liquid flow, oxygen levels continue to logarithmically ascend up to the design air injection, where O_2 then observes a slower trend increase in concentration. Carbon dioxide shows a more

exponential decrease with increasing air injection, mostly due to the larger concentrations values than seen in the oxygen profile.

The tested air-lift clearly shows the ability to sufficiently control oxygen and carbon dioxide over the calibrated and theoretical gas flow range for a broodstock application. It appears that Malone and Gudipati (2005b) developed a large reserve capacity when constructing the air injection guidelines, as the design Q_G represents an oxygen concentration near 8.4 mg l^{-1} and CO_2 near 2.8 mg l^{-1}, satisfactory for the recommendations. On the contrary, a much lower gas flow of 1,100 provides sufficient aeration and degasification as well, keeping concentrations near 7.5 mg O_2 l^{-1} and 5.2 mg CO_2 l^{-1}. However, it simply conveys the safety factors Malone and Gudipati incorporated for variability and adversity in a RAS setting, and stands as a conservative estimate. The author concludes the 20.3 cm air-lift experimental gas range has the ability to support the tested broodstock application based on the noted assumptions and steady state conditions, and if extrapolations were considered feasible, sufficient gas management would be provided for the remaining.

Warmwater Marine Fingerling Evaluation at F = 8.5 kg day^{-1}

Figure 4-3 shows the resulting concentration profiles for varying gas flows in a fingerling application, where feed rate was raised to 8.5 kg dry feed day^{-1}. Doubling the daily feed rate seems to have a significant effect on dissolved gas management as oxygen levels were lowered and carbon dioxide trends rose past those seen in Figure 4-2. The design Q_G still remains a conservative estimate based on extrapolated observations, as concentrations neared 7.6 mg O_2 l^{-1} and 5.4 mg CO_2 l^{-1}. The fingerling category diversifies itself from the broodstock category as it portrays a minimum Q_G, 950 l min^{-1}, at which O_2 reaches the threshold 5 mg l^{-1}. The remaining portion to the left of 950 l min^{-1} displays the stress zone, where O_2 levels begin to drop below 5 mg l^{-1}.

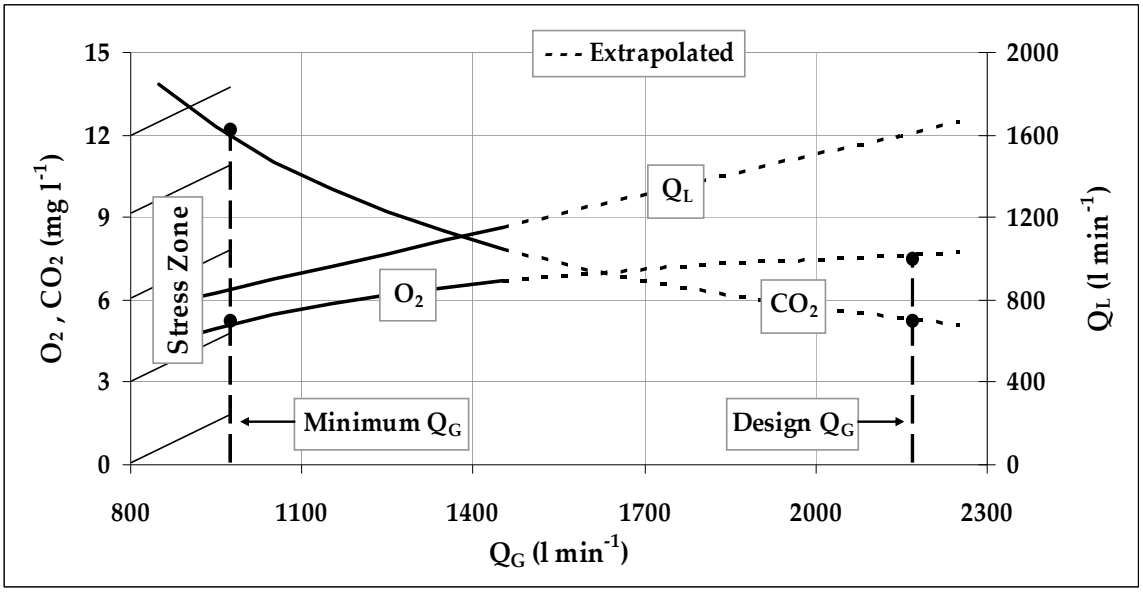


Figure 4-3. Resulting O_2 and CO_2 profiles along with water delivery rates for a fingerling environment (F = 8.5 kg day^{-1}) employing a 20.3 cm air-lift over a particular range of gas flows.

Meanwhile, however, carbon dioxide was still sufficiently maintained below the target 20 mg l^{-1}, at 12.2 mg l^{-1} for the minimum Q_G and barely approached 15 mg l^{-1} at the lowest tested Q_G.

The fingerling plot further validates that oxygen limitations exist in gas transfer design for air-lifted applications, as drawn in Chapters 2 and 3. Air-lifts must be designed and operated for oxygen management, not carbon dioxide, in the result that CO_2 will be concurrently controlled. The safe operating range for the fingerling application was set at the minimum 950 l min^{-1} to 1,415 l min^{-1} and up to 2,250 l min^{-1} included in the extrapolations, if allowed. Adapting design recommendations for air injection only, Figure 4-3 shows the recurring safety factor to accommodate system variability, approximately 2.2 for the fingerling case.

Warmwater Marine Growout Evaluation at F = 17 kg day^{-1}

The final analysis incorporated the intensive growout category, fed at 17 kg dry feed day^{-1}. The same gas flow range and theoretical extrapolations for the

fingerling and broodstock category were tested and presented in Figure 4-4. A considerably larger stress zone was witnessed immediately, reducing the Q_G operating zone between 1,700 and 2,250 l min^{-1}, much smaller than the fingerling case. The minimum Q_G increased to approximately 1,700 l min^{-1}, resulting in a carbon dioxide concentration of 12.4 mg l^{-1} at the target 5 mg O_2 l^{-1}.

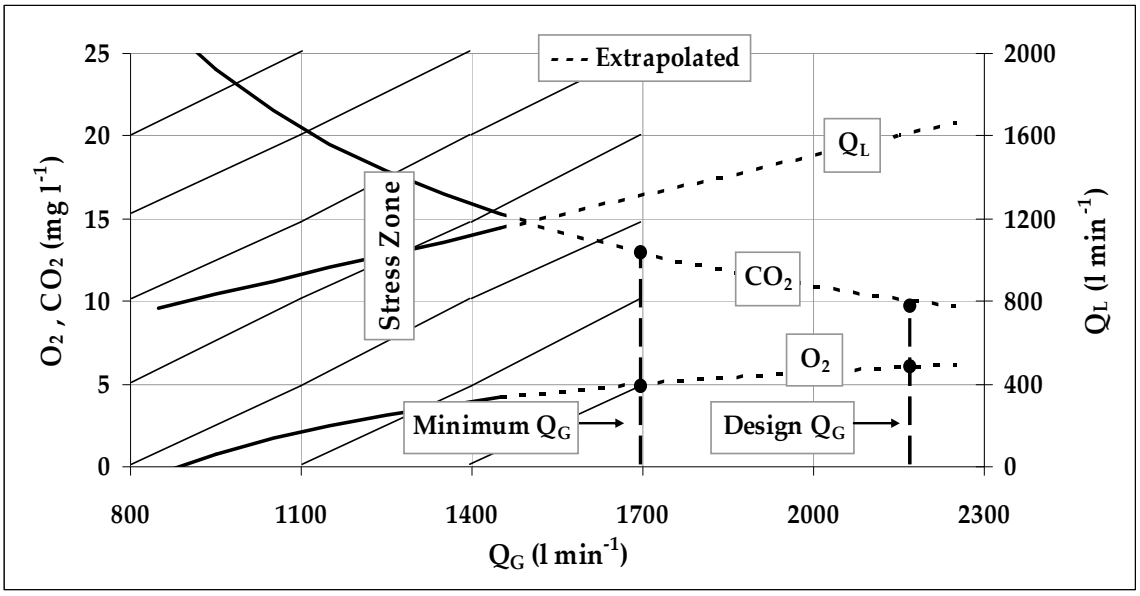


Figure 4-4. Resulting O_2 and CO_2 profiles along with water delivery rates for a growout environment (F = 17 kg day^{-1}) employing a 20.3 cm air-lift over a particular range of gas flows.

The resulting Q_G safety factor then becomes a marginal 1.2, leaving minimal room for operational and design error. For example, the potential design Q_G results in an oxygen concentration at 6 mg O_2 l^{-1} (CO_2 at 10 mg l^{-1}), allowing a 1 mg l^{-1} dissolved oxygen reserve in the best case before crossing 5 mg l^{-1}. As gas flow reduced to approximately 1,100 l min^{-1}, oxygen dropped to almost 2 mg l^{-1}, near lethal even for the highly resistant tilapia (Timmons et al., 2001).

As shown, the tested air-lift configuration can potentially support a growout system at 80% of the recommended air injection rate. However, careful consideration should be given as the operating Q_G zone incorporates extrapolated values only, excluding all boundary limits from Eq. 2-6. Malone

and Gudipati (2005b) took such encounters into consideration, per their decision to include supplemental in-tank air for oxygen and carbon dioxide control. Their design Q_G still stands as a conservative estimate for air-lift operation, yet it is unwise to rely solely on air-lifts for dissolved gas management in this particular growout RAS.

CONCLUSION

The tested analysis can be manipulated for a number of feed rates, and will expectedly show increases in oxygen trend lines and decreases in carbon dioxide as F decreases, with alternate results if F increases. Under certain circumstances, the air-lifted configuration has shown the ability to equal or supersede the oxygen consumption and carbon dioxide production rates for steady state conditions. From the tested mass balance analysis, one can estimate how a system will react to varying conditions.

Related to the particular conditions of interest only, the results are subject to change accordingly as parameters change. Temperature will show to play a major role in air-lift gas exchange performance, particularly dissolved oxygen. As temperature increases, O_2 saturation becomes relatively lower and in turn will increase the minimum Q_G required to support the target 5 mg O_2 l^{-1}. Also, the Q_G operating zone reduces, lowering the Q_G safety factor, and forces the Aquaculturist to resort to supplemental forms of dissolved gas management. Careful planning, consideration, and safety factors should therefore be given to air-lifted RAS design efforts to account for system variability and adversities that may be encountered in day-to-day operations.

CHAPTER 5: GLOBAL CONCLUSION

Further studies are recommended to help quantify the gas exchange guideline matrix for air-lifted RAS applications, including various diameter air-lifts for both marine and freshwater environments and their gas transfer response to varying parameters; such as temperature, salinity, alkalinity, submergence to lift ratios, gas to liquid ratios, and air injection devices. A cost analysis determining aeration and stripping efficiencies should also complement the gas transfer rates, and comparisons should be drawn to electrically pumped systems. Air-lifts also seem capable of potentially supporting foam fractionation treatment in RAS facilities. Research and development to modify air-lifts for such treatment is also encouraged.

The simple operation of air-lifts receiving blown air is a robust pumping alternative and is particularly well suited for recirculation applications where space and costs are limited. The consolidation of physical and chemical unit operations has shown water circulation and gas exchange capabilities under low-lift conditions. Based on the results, aeration kinetics prove to control the gas transfer design of air-lifts; simply put if the oxygen requirements are met, adequate CO_2 levels will be concurrently provided. The presented steady state analysis data consists of estimations only, and although air-lifts show promising gas exchange potential, with the ability to meet certain RAS system requirements, supplemental forms of aeration or degasification may be required for intensive applications.

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APPENDIX A:
EXPERIMENTAL AIR-LIFT DATA COLLECTED AT HUBBS SEA WORLD RESEARCH INSTITUTE (HSWRI)

AERATION STUDIES

20.3 cm air-lift_850 l air min^{-1}

30.5 cm lift_Trial 1_10/1/2008

Air-lift	20.3	cm	$Q_{L,ave}$	903.78	l min^{-1}
Salinity	33	ppt	$Q_{G,ave}$	849.35	l min^{-1}
C_s'	9.36	mg l^{-1}	$Q_G:Q_L$	0.94	

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		$C_{out} - C_t$	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
1:34:56 PM	19.6	19.4	9.36	9.3	-0.06	0.00	-0.078
1:35:27 PM	19.6	19.4	9.36	9.3	-0.06	0.00	-0.078
1:35:57 PM	19.6	19.4	9.37	9.3	-0.07	-0.01	-0.091
1:36:27 PM	19.6	19.5	9.37	9.3	-0.07	-0.01	-0.091
1:36:57 PM	19.6	19.5	9.36	9.3	-0.06	0.00	-0.078
1:37:27 PM	19.6	19.5	9.35	9.3	-0.05	0.01	-0.065
1:37:57 PM	19.6	19.5	9.27	9.2	-0.07	0.09	-0.091
1:38:27 PM	19.6	19.5	9.12	9.2	0.08	0.24	0.104
1:38:57 PM	19.6	19.5	8.77	9.1	0.33	0.59	0.429
1:39:27 PM	19.6	19.5	8.37	9.0	0.63	0.99	0.820
1:39:57 PM	19.6	19.5	8.06	8.9	0.84	1.30	1.093
1:40:27 PM	19.6	19.5	7.76	8.8	1.04	1.60	1.354
1:40:57 PM	19.6	19.5	7.55	8.8	1.25	1.81	1.627
1:41:27 PM	19.6	19.5	7.38	8.7	1.32	1.98	1.718
1:41:57 PM	19.6	19.5	7.21	8.7	1.49	2.15	1.939
1:42:27 PM	19.6	19.5	7.10	8.7	1.60	2.26	2.082
1:42:57 PM	19.6	19.5	6.94	8.7	1.76	2.42	2.291
1:43:27 PM	19.6	19.5	6.84	8.7	1.86	2.52	2.421
1:43:57 PM	19.6	19.5	6.73	8.6	1.87	2.63	2.434
1:44:27 PM	19.6	19.5	6.63	8.6	1.97	2.73	2.564
1:44:57 PM	19.6	19.5	6.56	8.6	2.04	2.80	2.655
1:45:27 PM	19.6	19.5	6.53	8.6	2.07	2.83	2.694
1:45:57 PM	19.6	19.5	6.46	8.6	2.14	2.90	2.785
1:46:27 PM	19.6	19.5	6.44	8.6	2.16	2.92	2.811
1:46:57 PM	19.6	19.5	6.41	8.6	2.19	2.95	2.850
1:47:27 PM	19.6	19.5	6.35	8.5	2.15	3.01	2.798
1:47:57 PM	19.6	19.5	6.32	8.6	2.28	3.04	2.967

30.5 cm lift_Trial 1_10/1/2008 (continued)

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		$C_{out} - C_t$	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
1:48:27 PM	19.6	19.5	6.56	8.7	2.14	2.80	2.785
1:48:57 PM	19.6	19.5	6.99	8.8	1.81	2.37	2.356
1:49:27 PM	19.6	19.5	7.41	8.9	1.49	1.95	1.939
1:49:57 PM	19.6	19.5	7.76	9.0	1.24	1.60	1.614
1:50:27 PM	19.6	19.5	8.02	9.1	1.08	1.34	1.406
1:50:57 PM	19.6	19.5	8.23	9.1	0.87	1.13	1.132
1:51:27 PM	19.6	19.5	8.40	9.1	0.70	0.96	0.911
1:51:57 PM	19.6	19.5	8.55	9.2	0.65	0.81	0.846

30.5 cm lift_Trial 2_10/1/2008

Air-lift	20.3	cm	$Q_{L,ave}$	904.23	l min^{-1}
Salinity	33	ppt	$Q_{G,ave}$	849.35	l min^{-1}
C_s'	9.29	mg l^{-1}	$Q_G:Q_L$	0.94	

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		$C_{out} - C_t$	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
2:27:08 PM	19.6	19.5	9.29	9.2	-0.09	0.00	-0.117
2:27:38 PM	19.6	19.5	9.21	9.2	-0.01	0.08	-0.013
2:28:08 PM	19.6	19.5	9.06	9.2	0.14	0.23	0.182
2:28:38 PM	19.6	19.5	8.71	9.2	0.49	0.58	0.638
2:29:08 PM	19.6	19.5	8.31	9.2	0.89	0.98	1.159
2:29:38 PM	19.6	19.5	8.0	9.2	1.20	1.29	1.563
2:30:08 PM	19.6	19.5	7.7	9.1	1.40	1.59	1.823
2:30:38 PM	19.6	19.5	7.49	9.1	1.61	1.80	2.096
2:31:08 PM	19.6	19.5	7.32	9.0	1.68	1.97	2.188
2:31:38 PM	19.6	19.5	7.13	8.9	1.77	2.16	2.305
2:32:08 PM	19.6	19.5	7.02	8.8	1.78	2.27	2.318
2:32:38 PM	19.6	19.5	6.86	8.7	1.84	2.43	2.396
2:33:08 PM	19.6	19.5	6.76	8.7	1.94	2.53	2.526
2:33:38 PM	19.6	19.5	6.65	8.6	1.95	2.64	2.539
2:34:08 PM	19.6	19.5	6.55	8.6	2.05	2.74	2.669
2:34:38 PM	19.6	19.5	6.48	8.6	2.12	2.81	2.760

30.5 cm lift_Trial 2_10/1/2008 (continued)

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		$C_{out} - C_t$	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
2:35:08 PM	19.6	19.5	6.45	8.6	2.15	2.84	2.799
2:35:38 PM	19.6	19.5	6.38	8.6	2.22	2.91	2.891
2:36:08 PM	19.6	19.5	6.36	8.5	2.14	2.93	2.786
2:36:38 PM	19.6	19.5	6.33	8.5	2.17	2.96	2.826
2:37:08 PM	19.6	19.5	6.21	8.5	2.29	3.08	2.982
2:37:38 PM	19.6	19.6	6.17	8.5	2.33	3.12	3.034
2:38:08 PM	19.6	19.6	6.08	8.5	2.42	3.21	3.151
2:38:38 PM	19.6	19.6	6.02	8.4	2.38	3.27	3.099
2:39:08 PM	19.6	19.6	5.98	8.4	2.42	3.31	3.151
2:39:38 PM	19.6	19.6	5.99	8.4	2.41	3.30	3.138
2:40:08 PM	19.6	19.6	6.12	8.5	2.38	3.17	3.099
2:40:38 PM	19.6	19.6	6.34	8.6	2.26	2.95	2.943
2:41:08 PM	19.6	19.6	6.56	8.7	2.14	2.73	2.786
2:41:38 PM	19.6	19.6	6.99	8.8	1.81	2.30	2.357
2:42:08 PM	19.6	19.6	7.44	8.9	1.46	1.85	1.901
2:42:38 PM	19.6	19.6	7.79	9.0	1.21	1.50	1.576
2:43:08 PM	19.6	19.6	8.05	9.0	0.95	1.24	1.237
2:43:38 PM	19.6	19.6	8.26	9.0	0.74	1.03	0.964
2:44:08 PM	19.6	19.6	8.43	9.1	0.67	0.86	0.872
2:44:38 PM	19.6	19.6	8.58	9.1	0.52	0.71	0.677
2:45:08 PM	19.6	19.6	8.62	9.1	0.48	0.67	0.625

38.1 cm lift_Trial 1_10/1/2008

Air-lift	20.3	cm	$Q_{L,ave}$	748.11	l min^{-1}
Salinity	33	ppt	$Q_{G,ave}$	849.35	l min^{-1}
C_s'	9.32	mg l^{-1}	Q_G:Q_L	1.14	

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		$C_{out} - C_t$	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
3:17:52 PM	19.7	19.6	9.32	9.2	-0.12	0.00	-0.129
3:18:22 PM	19.7	19.6	9.28	9.2	-0.08	0.04	-0.086
3:18:52 PM	19.7	19.6	9.26	9.2	-0.06	0.06	-0.065

38.1 cm lift_Trial 1_10/1/2008 (continued)

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		$C_{out} - C_t$	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
3:19:22 PM	19.7	19.6	9.24	9.2	-0.04	0.08	-0.043
3:19:52 PM	19.7	19.6	9.24	9.2	-0.04	0.08	-0.043
3:20:22 PM	19.7	19.6	9.23	9.2	-0.03	0.09	-0.032
3:20:52 PM	19.7	19.6	9.20	9.1	-0.10	0.12	-0.108
3:21:22 PM	19.7	19.6	9.10	9.1	0.00	0.22	0.000
3:21:52 PM	19.7	19.6	9.05	9.0	-0.05	0.27	-0.054
3:22:22 PM	19.7	19.6	8.87	8.9	0.03	0.45	0.032
3:22:52 PM	19.7	19.6	8.63	8.8	0.17	0.69	0.183
3:23:22 PM	19.7	19.6	8.41	8.7	0.29	0.91	0.312
3:23:52 PM	19.7	19.6	8.32	8.7	0.38	1.00	0.409
3:24:22 PM	19.7	19.6	8.26	8.6	0.34	1.06	0.366
3:24:52 PM	19.7	19.6	7.98	8.6	0.62	1.34	0.668
3:25:22 PM	19.7	19.6	7.93	8.6	0.67	1.39	0.722
3:25:52 PM	19.7	19.6	7.84	8.6	0.76	1.48	0.819
3:26:22 PM	19.7	19.6	7.64	8.6	0.96	1.68	1.034
3:26:52 PM	19.7	19.6	7.40	8.5	1.10	1.92	1.185
3:27:22 PM	19.6	19.6	7.19	8.5	1.31	2.13	1.411
3:27:52 PM	19.6	19.6	6.97	8.5	1.53	2.35	1.648
3:28:22 PM	19.6	19.6	6.79	8.5	1.71	2.53	1.842
3:28:52 PM	19.6	19.6	6.67	8.5	1.83	2.65	1.971
3:29:22 PM	19.6	19.6	6.57	8.4	1.83	2.75	1.971
3:29:52 PM	19.6	19.6	6.50	8.4	1.90	2.82	2.047
3:30:22 PM	19.6	19.6	6.41	8.4	1.99	2.91	2.144
3:30:52 PM	19.6	19.6	6.32	8.5	2.18	3.00	2.348
3:31:22 PM	19.6	19.6	6.27	8.6	2.33	3.05	2.510
3:31:52 PM	19.6	19.6	6.36	8.7	2.34	2.96	2.521
3:32:22 PM	19.6	19.6	6.61	8.8	2.19	2.71	2.359
3:32:52 PM	19.6	19.6	6.84	8.9	2.06	2.48	2.219
3:33:22 PM	19.6	19.6	7.04	9.0	1.96	2.28	2.111
3:33:52 PM	19.6	19.6	7.23	9.0	1.77	2.09	1.907
3:34:22 PM	19.6	19.6	7.38	9.0	1.62	1.94	1.745
3:34:52 PM	19.6	19.6	7.48	9.1	1.62	1.84	1.745
3:35:22 PM	19.6	19.6	7.59	9.1	1.51	1.73	1.627
3:35:52 PM	19.6	19.6	7.68	9.1	1.42	1.64	1.530
3:36:22 PM	19.6	19.6	7.74	9.1	1.36	1.58	1.465

38.1 cm lift_Trial 2_10/1/2008

Air-lift	**20.3**	**cm**	$Q_{L,ave}$	**748.09**	**l min^{-1}**
Salinity	**33**	**ppt**	$Q_{G,ave}$	**849.35**	**l min^{-1}**
C_s'	**9.18**	**mg l^{-1}**	Q_G:Q_L	**1.14**	

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		C_{out} - C_t	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
4:18:29 PM	19.7	19.6	9.18	9.1	-0.08	0.00	-0.086
4:18:59 PM	19.7	19.6	9.18	9.1	-0.08	0.00	-0.086
4:19:29 PM	19.7	19.6	9.16	9.1	-0.06	0.02	-0.065
4:19:59 PM	19.7	19.6	9.15	9.1	-0.05	0.03	-0.054
4:20:29 PM	19.7	19.6	9.12	9.1	-0.02	0.06	-0.022
4:20:59 PM	19.7	19.6	9.02	9.1	0.08	0.16	0.086
4:21:29 PM	19.7	19.6	8.97	9.1	0.13	0.21	0.140
4:21:59 PM	19.7	19.6	8.79	9.1	0.31	0.39	0.334
4:22:29 PM	19.7	19.6	8.55	9.0	0.45	0.63	0.485
4:22:59 PM	19.7	19.6	8.33	8.9	0.57	0.85	0.614
4:23:29 PM	19.7	19.6	8.24	8.8	0.56	0.94	0.603
4:23:59 PM	19.7	19.6	8.18	8.7	0.52	1.00	0.560
4:24:29 PM	19.7	19.6	7.90	8.7	0.80	1.28	0.862
4:24:59 PM	19.7	19.6	7.85	8.5	0.65	1.33	0.700
4:25:29 PM	19.7	19.6	7.76	8.5	0.74	1.42	0.797
4:25:59 PM	19.7	19.6	7.56	8.5	0.94	1.62	1.013
4:26:29 PM	19.7	19.6	7.32	8.5	1.18	1.86	1.271
4:26:59 PM	19.7	19.6	7.07	8.5	1.43	2.11	1.540
4:27:29 PM	19.7	19.6	6.85	8.4	1.55	2.33	1.670
4:27:59 PM	19.7	19.6	6.67	8.4	1.73	2.51	1.864
4:28:29 PM	19.7	19.7	6.55	8.4	1.85	2.63	1.993
4:28:59 PM	19.7	19.7	6.45	8.4	1.95	2.73	2.101
4:29:29 PM	19.7	19.7	6.38	8.4	2.02	2.80	2.176
4:29:59 PM	19.7	19.7	6.29	8.3	2.01	2.89	2.165
4:30:29 PM	19.7	19.7	6.20	8.3	2.10	2.98	2.262
4:30:59 PM	19.7	19.7	6.15	8.3	2.15	3.03	2.316
4:31:29 PM	19.7	19.7	6.24	8.4	2.16	2.94	2.327
4:31:59 PM	19.7	19.7	6.49	8.5	2.01	2.69	2.165
4:32:29 PM	19.7	19.7	6.72	8.6	1.88	2.46	2.025
4:32:59 PM	19.7	19.7	6.86	8.7	1.84	2.32	1.982
4:33:29 PM	19.7	19.7	7.01	8.8	1.79	2.17	1.928

38.1 cm lift_Trial 2_10/1/2008 (continued)

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		$C_{out} - C_t$	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
4:33:59 PM	19.7	19.7	7.19	9.0	1.81	1.99	1.950
4:34:29 PM	19.7	19.7	7.35	9.0	1.65	1.83	1.777
4:34:59 PM	19.7	19.7	7.42	9.0	1.58	1.76	1.702
4:35:29 PM	19.7	19.7	7.50	9.2	1.70	1.68	1.831
4:35:59 PM	19.7	19.7	7.61	9.2	1.59	1.57	1.713

45.7 cm lift_Trial 1_10/2/2008

Air-lift	20.3	cm	$Q_{L,ave}$	644.09	l min^{-1}
Salinity	33	ppt	$Q_{G,ave}$	849.35	l min^{-1}
C_s'	9.39	mg l^{-1}	Q_G:Q_L	1.32	

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		$C_{out} - C_t$	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
7:55:48 AM	19.5	19.4	9.39	9.3	-0.09	0.00	-0.083
7:56:19 AM	19.5	19.4	9.38	9.3	-0.08	0.01	-0.074
7:56:49 AM	19.5	19.4	9.38	9.3	-0.08	0.01	-0.074
7:57:19 AM	19.5	19.4	9.37	9.3	-0.07	0.02	-0.065
7:57:49 AM	19.5	19.4	9.36	9.3	-0.06	0.03	-0.056
7:58:19 AM	19.5	19.4	9.36	9.3	-0.06	0.03	-0.056
7:58:49 AM	19.5	19.4	9.33	9.3	-0.03	0.06	-0.028
7:59:19 AM	19.5	19.4	9.19	9.2	0.01	0.20	0.009
7:59:49 AM	19.5	19.4	8.84	9.1	0.26	0.55	0.241
8:00:19 AM	19.5	19.4	8.37	9.0	0.63	1.02	0.584
8:00:49 AM	19.5	19.4	7.88	8.9	1.02	1.51	0.946
8:01:19 AM	19.5	19.4	7.55	8.8	1.25	1.84	1.159
8:01:49 AM	19.4	19.4	7.28	8.8	1.52	2.11	1.410
8:02:19 AM	19.5	19.4	7.07	8.8	1.73	2.32	1.605
8:02:49 AM	19.5	19.4	6.84	8.7	1.86	2.55	1.725
8:03:19 AM	19.5	19.4	6.56	8.7	2.14	2.83	1.985
8:03:49 AM	19.5	19.4	6.39	8.6	2.21	3.00	2.050
8:04:19 AM	19.5	19.4	6.24	8.6	2.36	3.15	2.189
8:04:49 AM	19.5	19.4	6.11	8.6	2.49	3.28	2.309

45.7 cm lift_Trial 1_10/2/2008 (continued)

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		$C_{out} - C_t$	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
8:05:19 AM	19.5	19.4	5.99	8.6	2.61	3.40	2.421
8:05:49 AM	19.5	19.4	5.94	8.6	2.66	3.45	2.467
8:06:19 AM	19.5	19.4	5.97	8.7	2.73	3.42	2.532
8:06:49 AM	19.5	19.4	6.21	8.8	2.59	3.18	2.402
8:07:19 AM	19.5	19.4	6.49	8.8	2.31	2.90	2.143
8:07:49 AM	19.5	19.4	6.83	8.9	2.07	2.56	1.920
8:08:19 AM	19.5	19.4	7.15	9.0	1.85	2.24	1.716
8:08:49 AM	19.5	19.4	7.44	9.0	1.56	1.95	1.447
8:09:19 AM	19.5	19.4	7.65	9.0	1.35	1.74	1.252
8:09:49 AM	19.5	19.4	7.90	9.1	1.20	1.49	1.113
8:10:19 AM	19.5	19.4	8.07	9.1	1.03	1.32	0.955
8:10:49 AM	19.5	19.4	8.21	9.1	0.89	1.18	0.825
8:11:19 AM	19.5	19.4	8.35	9.1	0.75	1.04	0.696
8:11:49 AM	19.5	19.4	8.44	9.2	0.76	0.95	0.705

45.7 cm lift_Trial 2_10/2/2008

Air-lift	20.3	cm	$Q_{L,ave}$	574.26	l min^{-1}
Salinity	33	ppt	$Q_{G,ave}$	849.35	l min^{-1}
C_s'	9.04	mg l^{-1}	Q_G:Q_L	1.48	

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		$C_{out} - C_t$	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
8:29:10 AM	19.5	19.4	9.04	9.2	0.16	0.00	0.132
8:29:42 AM	19.5	19.4	9.04	9.2	0.16	0.00	0.132
8:30:16 AM	19.5	19.4	9.05	9.2	0.15	-0.01	0.124
8:30:45 AM	19.5	19.4	9.05	9.2	0.15	-0.01	0.124
8:31:15 AM	19.5	19.4	9.04	9.2	0.16	0.00	0.132
8:31:45 AM	19.5	19.4	9.03	9.2	0.17	0.01	0.141
8:32:15 AM	19.5	19.4	8.97	9.2	0.23	0.07	0.190
8:32:45 AM	19.5	19.4	8.71	9.1	0.39	0.33	0.323
8:33:16 AM	19.5	19.4	8.35	9.0	0.65	0.69	0.538
8:33:45 AM	19.5	19.4	7.93	8.9	0.97	1.11	0.802

45.7 cm lift_Trial 2_10/2/2008 (continued)

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		$C_{out} - C_t$	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
8:34:15 AM	19.5	19.4	7.50	8.8	1.30	1.54	1.075
8:34:55 AM	19.5	19.4	7.04	8.8	1.76	2.00	1.455
8:35:25 AM	19.5	19.4	6.78	8.7	1.92	2.26	1.588
8:35:55 AM	19.5	19.4	6.51	8.7	2.19	2.53	1.811
8:36:24 AM	19.5	19.4	6.29	8.6	2.31	2.75	1.910
8:36:54 AM	19.5	19.4	6.12	8.6	2.48	2.92	2.051
8:37:24 AM	19.5	19.4	5.92	8.6	2.68	3.12	2.216
8:37:54 AM	19.5	19.4	5.77	8.6	2.83	3.27	2.340
8:38:24 AM	19.5	19.4	5.65	8.6	2.95	3.39	2.439
8:38:54 AM	19.5	19.4	5.55	8.5	2.95	3.49	2.439
8:39:24 AM	19.5	19.4	5.54	8.6	3.06	3.50	2.530
8:39:54 AM	19.5	19.4	5.74	8.6	2.86	3.30	2.365
8:40:24 AM	19.5	19.4	6.07	8.7	2.63	2.97	2.175
8:40:54 AM	19.5	19.4	6.45	8.8	2.35	2.59	1.943
8:41:24 AM	19.5	19.4	6.77	8.9	2.13	2.27	1.761
8:41:54 AM	19.5	19.4	7.11	8.9	1.79	1.93	1.480
8:42:24 AM	19.5	19.4	7.38	9.0	1.62	1.66	1.340
8:42:54 AM	19.5	19.4	7.61	9.0	1.39	1.43	1.149
8:43:24 AM	19.5	19.4	7.82	9.0	1.18	1.22	0.976
8:43:54 AM	19.5	19.4	7.95	9.1	1.15	1.09	0.951
8:44:29 AM	19.5	19.4	8.07	9.1	1.03	0.97	0.852
8:45:01 AM	19.5	19.4	8.18	9.1	0.92	0.86	0.761
8:45:32 AM	19.5	19.4	8.28	9.1	0.82	0.76	0.678
8:46:02 AM	19.5	19.4	8.38	9.1	0.72	0.66	0.595

OTR and $C_{deficit}$ Linear Regression Summary for 20.3 cm air-lift at 850 l min^{-1} air

Lift [cm]	Trial	OTR Coefficient for $C_{deficit}$ equations	R^2
30.5	1	$OTR = 0.9491*C_{deficit}$	0.987
30.5	2	$OTR = 0.9826*C_{deficit}$	0.981
38.1	1	$OTR = 0.7752*C_{deficit}$	0.857
38.1	2	$OTR = 0.7900*C_{deficit}$	0.908
45.7	1	$OTR = 0.7112*C_{deficit}$	0.986
45.7	2	$OTR = 0.7282*C_{deficit}$	0.985

AERATION STUDIES (continued)

20.3 cm air-lift_1,132 l air min^{-1}

38.1 cm lift_Trial 1_9/29/2008

Air-lift	20.3	cm	$Q_{L,ave}$	984.97	l min^{-1}
Salinity	33	ppt	$Q_{G,ave}$	1132.47	l min^{-1}
C_s'	8.84	mg l^{-1}	$Q_G:Q_L$	1.15	

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		$C_{out} - C_t$	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
3:42:37 PM	19.8	19.7	7.5	8.8	1.34	1.34	1.901
3:43:07 PM	19.8	19.7	7.5	8.8	1.33	1.34	1.886
3:43:37 PM	19.8	19.7	7.3	8.8	1.49	1.54	2.113
3:44:07 PM	19.8	19.7	7.3	8.8	1.49	1.54	2.113
3:44:37 PM	19.8	19.7	7.29	8.6	1.31	1.55	1.858
3:45:07 PM	19.8	19.7	7.07	8.6	1.53	1.77	2.170
3:45:37 PM	19.8	19.7	6.89	8.5	1.61	1.95	2.284
3:46:07 PM	19.8	19.7	6.77	8.5	1.73	2.07	2.454
3:46:37 PM	19.8	19.7	6.67	8.5	1.83	2.17	2.596
3:47:07 PM	19.8	19.7	6.60	8.4	1.80	2.24	2.553
3:47:37 PM	19.8	19.7	6.51	8.4	1.89	2.33	2.681
3:48:07 PM	19.8	19.7	6.42	8.4	1.98	2.42	2.808
3:48:37 PM	19.8	19.7	6.37	8.4	2.03	2.47	2.879
3:49:07 PM	19.8	19.7	6.46	8.5	2.04	2.38	2.893
3:49:37 PM	19.8	19.7	6.71	8.6	1.89	2.13	2.681
3:50:07 PM	19.8	19.7	6.94	8.7	1.76	1.90	2.496
3:50:37 PM	19.8	19.7	7.14	8.8	1.66	1.70	2.354
3:51:07 PM	19.8	19.7	7.33	8.8	1.47	1.51	2.085
3:51:37 PM	19.8	19.7	7.30	8.8	1.50	1.54	2.128
3:52:07 PM	19.8	19.7	7.30	8.8	1.50	1.54	2.128
3:52:37 PM	19.8	19.7	7.20	8.8	1.58	1.64	2.241
3:53:07 PM	19.8	19.7	7.30	8.8	1.49	1.54	2.113
3:53:37 PM	19.8	19.7	7.30	8.8	1.50	1.54	2.128
3:54:07 PM	19.8	19.7	7.40	8.8	1.44	1.44	2.042
3:54:37 PM	19.8	19.7	7.60	9.0	1.36	1.24	1.929
3:55:07 PM	19.8	19.7	8.00	9.0	1.04	0.84	1.475
3:55:37 PM	19.8	19.7	8.30	9.1	0.80	0.54	1.135

38.1 cm lift_Trial 1_9/29/2008 (continued)

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		$C_{out} - C_t$	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
3:56:07 PM	19.8	19.7	8.60	9.2	0.55	0.24	0.780
3:56:37 PM	19.8	19.7	8.70	9.2	0.48	0.14	0.681
3:57:07 PM	19.8	19.7	8.90	9.2	0.31	-0.06	0.440
3:57:37 PM	19.8	19.7	9.00	9.2	0.22	-0.16	0.312
3:58:07 PM	19.8	19.7	9.00	9.2	0.23	-0.16	0.326

38.1 cm lift_Trial 2_9/30/2008

Air-lift	20.3	cm	$Q_{L,ave}$	967.75	l min^{-1}
Salinity	33	ppt	$Q_{G,ave}$	1132.47	l min^{-1}
C_s'	9	mg l^{-1}	Q_G:Q_L	1.17	

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		$C_{out} - C_t$	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
2:29:40 PM	19.6	19.5	8.11	9.0	0.89	0.89	1.240
2:30:11 PM	19.6	19.5	8.11	9.0	0.89	0.89	1.240
2:30:41 PM	19.6	19.5	8.11	9.0	0.89	0.89	1.240
2:31:11 PM	19.6	19.5	8.11	9.0	0.89	0.89	1.240
2:31:41 PM	19.6	19.5	8.11	9.0	0.89	0.89	1.240
2:32:11 PM	19.6	19.5	8.11	9.0	0.89	0.89	1.240
2:32:41 PM	19.6	19.5	8.1	9.0	0.90	0.90	1.254
2:33:11 PM	19.6	19.5	8.05	8.9	0.85	0.95	1.185
2:33:41 PM	19.6	19.5	7.96	8.9	0.94	1.04	1.310
2:34:11 PM	19.6	19.5	7.76	8.8	1.04	1.24	1.449
2:34:41 PM	19.6	19.5	7.52	8.7	1.18	1.48	1.644
2:35:11 PM	19.6	19.5	7.31	8.6	1.29	1.69	1.798
2:35:41 PM	19.6	19.5	7.09	8.6	1.51	1.91	2.104
2:36:11 PM	19.6	19.6	6.91	8.5	1.59	2.09	2.216
2:36:41 PM	19.6	19.6	6.79	8.5	1.71	2.21	2.383
2:37:11 PM	19.6	19.6	6.69	8.5	1.81	2.31	2.522
2:37:41 PM	19.6	19.6	6.62	8.4	1.78	2.38	2.481
2:38:11 PM	19.6	19.6	6.53	8.4	1.87	2.47	2.606
2:38:41 PM	19.6	19.6	6.44	8.4	1.96	2.56	2.731

38.1 cm lift_Trial 2_9/30/2008 (continued)

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		$C_{out} - C_t$	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
2:39:11 PM	19.6	19.6	6.39	8.4	2.01	2.61	2.801
2:39:41 PM	19.6	19.6	6.48	8.5	2.02	2.52	2.815
2:40:11 PM	19.6	19.6	6.73	8.6	1.87	2.27	2.606
2:40:41 PM	19.6	19.6	6.96	8.7	1.74	2.04	2.425
2:41:11 PM	19.6	19.6	7.16	8.8	1.64	1.84	2.285
2:41:41 PM	19.6	19.6	7.35	8.8	1.45	1.65	2.021
2:42:11 PM	19.6	19.6	7.50	8.8	1.30	1.50	1.812
2:42:41 PM	19.6	19.6	7.60	8.9	1.30	1.40	1.812
2:43:11 PM	19.6	19.6	7.71	8.9	1.19	1.29	1.658
2:43:41 PM	19.6	19.6	7.80	8.9	1.10	1.20	1.533
2:44:11 PM	19.6	19.6	7.86	8.9	1.04	1.14	1.449
2:44:41 PM	19.6	19.6	7.90	8.9	1.00	1.10	1.394

45.7 cm lift_Trial 1_9/30/2008

Air-lift	20.3	cm	$Q_{L,ave}$	772.33	l min^{-1}
Salinity	33	ppt	$Q_{G,ave}$	1132.47	l min^{-1}
C_s'	9.4	mg l^{-1}	Q_G:Q_L	1.47	

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		$C_{out} - C_t$	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
10:11:02 AM	19.5	19.5	9.7	9.40	-0.30	-0.30	-0.334
10:11:32 AM	19.5	19.5	9.7	9.41	-0.29	-0.30	-0.323
10:12:02 AM	19.5	19.5	9.7	9.40	-0.30	-0.30	-0.334
10:12:32 AM	19.5	19.5	9.7	9.40	-0.30	-0.30	-0.334
10:13:02 AM	19.5	19.5	9.7	9.40	-0.30	-0.30	-0.334
10:13:32 AM	19.5	19.5	9.7	9.39	-0.31	-0.30	-0.345
10:14:03 AM	19.5	19.5	9.7	9.39	-0.31	-0.30	-0.345
10:14:32 AM	19.5	19.5	9.6	9.38	-0.22	-0.20	-0.245
10:15:02 AM	19.5	19.5	9.6	9.37	-0.23	-0.20	-0.256
10:15:33 AM	19.5	19.5	9.4	9.33	-0.07	0.00	-0.078
10:16:02 AM	19.5	19.5	9.2	9.27	0.07	0.20	0.078
10:16:32 AM	19.5	19.5	9.0	9.22	0.22	0.40	0.245

45.7 cm lift_Trial 1_9/30/2008 (continued)

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		$C_{out} - C_t$	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
10:17:02 AM	19.5	19.5	8.7	9.16	0.46	0.70	0.512
10:17:32 AM	19.5	19.5	8.5	9.10	0.60	0.90	0.667
10:18:02 AM	19.5	19.5	8.2	9.06	0.86	1.20	0.956
10:18:32 AM	19.5	19.5	8.0	9.04	1.04	1.40	1.157
10:19:02 AM	19.5	19.5	7.9	9.00	1.10	1.50	1.223
10:19:32 AM	19.5	19.5	7.7	8.99	1.29	1.70	1.435
10:20:02 AM	19.5	19.5	7.6	8.97	1.37	1.80	1.524
10:20:32 AM	19.5	19.5	7.5	8.96	1.46	1.90	1.624
10:21:03 AM	19.5	19.5	7.4	8.95	1.55	2.00	1.724
10:21:32 AM	19.5	19.5	7.3	8.92	1.62	2.10	1.802
10:22:02 AM	19.5	19.5	7.2	8.92	1.72	2.20	1.913
10:22:32 AM	19.5	19.5	7.4	9.00	1.60	2.00	1.779
10:23:02 AM	19.5	19.5	7.7	9.06	1.36	1.70	1.513
10:23:33 AM	19.5	19.5	7.9	9.12	1.22	1.50	1.357
10:24:02 AM	19.5	19.5	8.2	9.18	0.98	1.20	1.090
10:24:32 AM	19.5	19.5	8.4	9.21	0.81	1.00	0.901
10:25:02 AM	19.5	19.5	8.5	9.24	0.74	0.90	0.823
10:25:32 AM	19.5	19.5	8.7	9.26	0.56	0.70	0.623
10:26:02 AM	19.5	19.5	8.8	9.28	0.48	0.60	0.534
10:26:32 AM	19.5	19.5	8.9	9.30	0.40	0.50	0.445
10:27:02 AM	19.5	19.5	9.0	9.30	0.30	0.40	0.334
10:27:33 AM	19.5	19.5	9.0	9.32	0.32	0.40	0.356
10:28:02 AM	19.5	19.5	9.1	9.32	0.22	0.30	0.245
10:28:32 AM	19.5	19.5	9.1	9.33	0.23	0.30	0.256
10:29:02 AM	19.5	19.5	9.2	9.34	0.14	0.20	0.156

45.7 cm lift_Trial 2_9/30/2008

Air-lift	**20.3**	**cm**	$Q_{L,ave}$	**746.93**	**l min^{-1}**
Salinity	**33**	**ppt**	$Q_{G,ave}$	**1132.47**	**l min^{-1}**
C_s'	**9.1**	**mg l^{-1}**	Q_G:Q_L	**1.52**	

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		C_{out} - C_t	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
3:22:56 PM	19.6	19.6	8.34	9.1	0.76	0.76	0.817
3:23:27 PM	19.6	19.6	8.35	9.1	0.75	0.75	0.807
3:23:57 PM	19.6	19.6	8.35	9.1	0.75	0.75	0.807
3:24:27 PM	19.6	19.6	8.35	9.1	0.75	0.75	0.807
3:24:57 PM	19.6	19.6	8.36	9.1	0.74	0.74	0.796
3:25:27 PM	19.6	19.6	8.37	9.1	0.73	0.73	0.785
3:25:57 PM	19.6	19.6	8.38	9.1	0.72	0.72	0.774
3:26:27 PM	19.6	19.6	8.37	9.1	0.73	0.73	0.785
3:26:57 PM	19.6	19.6	8.32	9.0	0.68	0.78	0.731
3:27:27 PM	19.6	19.6	8.16	8.9	0.74	0.94	0.796
3:27:57 PM	19.6	19.6	7.96	8.9	0.94	1.14	1.011
3:28:27 PM	19.6	19.6	7.80	8.8	1.00	1.30	1.076
3:28:57 PM	19.6	19.6	7.65	8.8	1.15	1.45	1.237
3:29:27 PM	19.6	19.6	7.51	8.7	1.19	1.59	1.280
3:29:57 PM	19.6	19.6	7.36	8.7	1.34	1.74	1.441
3:30:27 PM	19.6	19.6	7.19	8.7	1.51	1.91	1.624
3:30:57 PM	19.6	19.6	7.03	8.6	1.57	2.07	1.689
3:31:27 PM	19.6	19.6	6.91	8.6	1.69	2.19	1.818
3:31:57 PM	19.6	19.6	6.85	8.6	1.75	2.25	1.882
3:32:27 PM	19.6	19.6	6.76	8.6	1.84	2.34	1.979
3:32:57 PM	19.6	19.6	6.69	8.6	1.91	2.41	2.054
3:33:27 PM	19.6	19.6	6.64	8.6	1.96	2.46	2.108
3:33:57 PM	19.6	19.6	6.59	8.6	2.01	2.51	2.162
3:34:27 PM	19.6	19.6	6.50	8.5	2.00	2.60	2.151
3:34:57 PM	19.6	19.6	6.43	8.5	2.07	2.67	2.226
3:35:27 PM	19.6	19.6	6.45	8.6	2.15	2.65	2.312
3:35:57 PM	19.6	19.6	6.57	8.7	2.13	2.53	2.291
3:36:27 PM	19.6	19.6	6.75	8.8	2.05	2.35	2.205
3:36:57 PM	19.6	19.6	6.96	8.8	1.84	2.14	1.979
3:37:27 PM	19.6	19.6	7.12	8.9	1.78	1.98	1.915
3:37:57 PM	19.6	19.6	7.27	8.9	1.63	1.83	1.753

45.7 cm lift_Trial 2_9/30/2008 (continued)

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		$C_{out} - C_t$	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
3:38:27 PM	19.6	19.6	7.37	8.9	1.53	1.73	1.646
3:38:57 PM	19.6	19.6	7.47	9.0	1.53	1.63	1.646
3:39:27 PM	19.6	19.6	7.55	9.0	1.45	1.55	1.560
3:39:57 PM	19.6	19.6	7.62	9.0	1.38	1.48	1.484
3:40:27 PM	19.6	19.6	7.67	9.0	1.33	1.43	1.431
3:40:57 PM	19.6	19.6	7.71	9.0	1.29	1.39	1.387
3:41:27 PM	19.6	19.6	7.77	9.0	1.23	1.33	1.323
3:41:57 PM	19.6	19.6	7.81	9.0	1.19	1.29	1.280
3:42:27 PM	19.6	19.6	7.86	9.0	1.14	1.24	1.226
3:42:57 PM	19.6	19.6	7.91	9.0	1.09	1.19	1.172
3:43:27 PM	19.6	19.6	7.96	9.1	1.14	1.14	1.226
3:43:57 PM	19.6	19.6	7.97	9.1	1.13	1.13	1.215

OTR and $C_{deficit}$ Linear Regression Summary for 20.3 cm air-lift at 1,132 l min^{-1} air

Lift [cm]	Trial	OTR Coefficient for $C_{deficit}$ equations	R^2
38.1	1	$OTR = 1.2726*C_{deficit}$	0.791
38.1	2	$OTR = 1.1310*C_{deficit}$	0.919
45.7	1	$OTR = 0.8588*C_{deficit}$	0.992
45.7	2	$OTR = 0.8935*C_{deficit}$	0.925

AERATION STUDIES (continued)

20.3 cm air-lift_1,415 l air min^{-1}

38.1 cm lift_Trial 1_9/30/2008

Headloss	**38.1**	**cm**	$Q_{L,ave}$	**1136.11**	**l min^{-1}**
Salinity	**33**	**ppt**	$Q_{G,ave}$	**1415.59**	**l min^{-1}**
C_s'	**9.1**	**mg l^{-1}**	$Q_G:Q_L$	**1.25**	

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		$C_{out} - C_t$	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
5:03:16 PM	19.7	19.6	8.74	9.1	0.36	0.36	0.589
5:03:47 PM	19.7	19.6	8.73	9.1	0.37	0.37	0.605
5:04:17 PM	19.7	19.6	8.73	9.1	0.37	0.37	0.605
5:04:47 PM	19.7	19.6	8.72	9.1	0.38	0.38	0.622
5:05:17 PM	19.7	19.6	8.72	9.2	0.48	0.38	0.785
5:05:47 PM	19.7	19.6	8.72	9.1	0.38	0.38	0.622
5:06:17 PM	19.7	19.6	8.65	9.1	0.45	0.45	0.736
5:06:47 PM	19.7	19.6	8.53	9.1	0.57	0.57	0.933
5:07:17 PM	19.7	19.6	8.31	9.0	0.69	0.79	1.129
5:07:47 PM	19.7	19.6	8.06	8.9	0.84	1.04	1.374
5:08:17 PM	19.7	19.6	7.84	8.8	0.96	1.26	1.571
5:08:47 PM	19.7	19.6	7.64	8.8	1.16	1.46	1.898
5:09:17 PM	19.7	19.6	7.46	8.7	1.24	1.64	2.029
5:09:47 PM	19.7	19.6	7.26	8.7	1.44	1.84	2.356
5:10:17 PM	19.7	19.6	7.11	8.7	1.59	1.99	2.601
5:10:47 PM	19.7	19.6	7.02	8.7	1.68	2.08	2.748
5:11:17 PM	19.7	19.6	6.94	8.6	1.66	2.16	2.716
5:11:47 PM	19.7	19.6	6.85	8.6	1.75	2.25	2.863
5:12:17 PM	19.7	19.6	6.76	8.6	1.84	2.34	3.010
5:12:47 PM	19.7	19.6	6.72	8.6	1.88	2.38	3.076
5:13:17 PM	19.7	19.6	6.68	8.6	1.92	2.42	3.141
5:13:47 PM	19.7	19.6	6.66	8.6	1.94	2.44	3.174
5:14:17 PM	19.7	19.6	6.61	8.6	1.99	2.49	3.256
5:14:47 PM	19.7	19.6	6.58	8.6	2.02	2.52	3.305
5:15:17 PM	19.7	19.6	6.66	8.7	2.04	2.44	3.337
5:15:47 PM	19.7	19.6	6.91	8.8	1.89	2.19	3.092
5:16:17 PM	19.7	19.6	7.20	8.9	1.70	1.90	2.781

38.1 cm lift_Trial 1_9/30/2008 (continued)

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		$C_{out} - C_t$	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
5:16:47 PM	19.7	19.6	7.48	8.9	1.42	1.62	2.323
5:17:17 PM	19.7	19.6	7.71	9.0	1.29	1.39	2.110
5:17:47 PM	19.7	19.6	7.88	9.0	1.12	1.22	1.832
5:18:17 PM	19.7	19.6	8.00	9.0	1.00	1.10	1.636

38.1 cm lift_Trial 2_9/30/2008

Air-lift	20.3	cm	$Q_{L,ave}$	1109.5	l min^{-1}
Salinity	33	ppt	$Q_{G,ave}$	1415.59	l min^{-1}
C_s'	9.10	mg l^{-1}	Q_G:Q_L	1.28	

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		$C_{out} - C_t$	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
5:41:41 PM	19.7	19.6	8.57	9.1	0.53	0.53	0.847
5:42:12 PM	19.7	19.6	8.56	9.1	0.54	0.54	0.863
5:42:42 PM	19.7	19.6	8.56	9.1	0.54	0.54	0.863
5:43:12 PM	19.7	19.6	8.56	9.1	0.54	0.54	0.863
5:43:42 PM	19.7	19.6	8.56	9.1	0.54	0.54	0.863
5:44:12 PM	19.7	19.6	8.54	9.1	0.56	0.56	0.895
5:44:42 PM	19.7	19.6	8.5	9.1	0.60	0.60	0.959
5:45:12 PM	19.7	19.6	8.38	9.0	0.62	0.72	0.991
5:45:42 PM	19.7	19.6	8.21	8.9	0.69	0.89	1.102
5:46:12 PM	19.7	19.6	7.96	8.9	0.94	1.14	1.502
5:46:42 PM	19.7	19.6	7.75	8.8	1.05	1.35	1.678
5:47:12 PM	19.7	19.6	7.57	8.8	1.23	1.53	1.965
5:47:42 PM	19.7	19.6	7.41	8.8	1.39	1.69	2.221
5:48:12 PM	19.7	19.6	7.25	8.7	1.45	1.85	2.317
5:48:42 PM	19.7	19.6	7.11	8.7	1.59	1.99	2.540
5:49:12 PM	19.7	19.6	7.00	8.7	1.70	2.10	2.716
5:49:42 PM	19.7	19.6	6.92	8.7	1.78	2.18	2.844
5:50:12 PM	19.7	19.6	6.87	8.7	1.83	2.23	2.924
5:50:42 PM	19.7	19.6	6.82	8.7	1.88	2.28	3.004
5:51:27 PM	19.7	19.6	6.74	8.7	1.96	2.36	3.131

38.1 cm lift_Trial 2_9/30/2008 (continued)

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		$C_{out} - C_t$	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
5:51:57 PM	19.7	19.6	6.71	8.7	1.99	2.39	3.179
5:52:38 PM	19.7	19.6	6.64	8.6	1.96	2.46	3.131
5:53:38 PM	19.7	19.6	6.61	8.6	1.99	2.49	3.179
5:54:38 PM	19.7	19.6	7.23	8.8	1.57	1.87	2.508
5:56:13 PM	19.7	19.6	7.70	9.0	1.30	1.40	2.077
5:57:14 PM	19.7	19.6	8.03	9.0	0.97	1.07	1.550
5:58:19 PM	19.7	19.6	8.16	9.0	0.84	0.94	1.342
5:59:22 PM	19.7	19.6	8.27	9.1	0.83	0.83	1.326

45.7 cm lift_Trial 1_10/1/2008

Air-lift	20.3	cm	$Q_{L,ave}$	922.99	l min^{-1}
Salinity	33	ppt	$Q_{G,ave}$	1415.59	l min^{-1}
C_s'	9.32	mg l^{-1}	Q_G:Q_L	1.53	

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		$C_{out} - C_t$	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
9:48:25 AM	19.4	19.3	9.32	9.3	-0.02	0.00	-0.027
9:48:56 AM	19.4	19.3	9.32	9.3	-0.02	0.00	-0.027
9:49:26 AM	19.4	19.3	9.33	9.3	-0.03	-0.01	-0.040
9:49:56 AM	19.4	19.3	9.32	9.3	-0.02	0.00	-0.027
9:50:26 AM	19.4	19.3	9.31	9.3	-0.01	0.01	-0.013
9:50:56 AM	19.4	19.3	9.25	9.3	0.05	0.07	0.066
9:51:26 AM	19.4	19.3	9.15	9.3	0.15	0.17	0.199
9:51:56 AM	19.4	19.3	9.00	9.2	0.20	0.32	0.266
9:52:26 AM	19.4	19.3	8.8	9.1	0.30	0.52	0.399
9:52:56 AM	19.4	19.3	8.54	9.1	0.56	0.78	0.744
9:53:26 AM	19.4	19.3	8.33	9.1	0.77	0.99	1.023
9:53:56 AM	19.4	19.3	8.14	9.0	0.86	1.18	1.143
9:54:26 AM	19.4	19.3	7.92	9.0	1.08	1.40	1.435
9:54:56 AM	19.4	19.3	7.76	9.0	1.24	1.56	1.648
9:55:26 AM	19.4	19.3	7.61	8.9	1.29	1.71	1.715
9:55:56 AM	19.4	19.3	7.50	8.9	1.40	1.82	1.861

45.7 cm lift_Trial 1_10/1/2008 (continued)

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		$C_{out} - C_t$	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
9:56:26 AM	19.4	19.3	7.38	8.9	1.52	1.94	2.020
9:56:56 AM	19.4	19.3	7.32	8.9	1.58	2.00	2.100
9:57:26 AM	19.5	19.3	7.25	8.9	1.65	2.07	2.193
9:57:56 AM	19.5	19.3	7.20	8.9	1.70	2.12	2.259
9:58:26 AM	19.5	19.3	7.13	8.9	1.77	2.19	2.353
9:58:56 AM	19.5	19.3	7.05	8.9	1.85	2.27	2.459
9:59:26 AM	19.5	19.3	6.98	8.9	1.92	2.34	2.552
9:59:56 AM	19.5	19.3	6.92	8.9	1.98	2.40	2.632
10:00:26 AM	19.4	19.3	6.89	8.9	2.01	2.43	2.672
10:00:56 AM	19.4	19.3	6.85	8.9	2.05	2.47	2.725
10:01:26 AM	19.4	19.3	6.81	8.9	2.09	2.51	2.778
10:01:56 AM	19.5	19.3	6.78	8.9	2.12	2.54	2.818
10:02:26 AM	19.5	19.3	6.74	8.9	2.16	2.58	2.871
10:02:56 AM	19.5	19.3	6.74	8.8	2.06	2.58	2.738
10:03:26 AM	19.4	19.3	6.70	8.9	2.20	2.62	2.924
10:03:56 AM	19.4	19.3	6.69	8.8	2.11	2.63	2.804
10:04:26 AM	19.5	19.3	6.68	8.8	2.12	2.64	2.818
10:05:01 AM	19.5	19.3	6.66	8.8	2.14	2.66	2.844
10:05:30 AM	19.5	19.3	6.64	8.8	2.16	2.68	2.871
10:06:00 AM	19.5	19.3	6.75	8.9	2.15	2.57	2.858
10:06:30 AM	19.5	19.3	6.99	9.0	2.01	2.33	2.672
10:07:00 AM	19.5	19.3	7.24	9	1.76	2.08	2.339
10:07:30 AM	19.5	19.3	7.47	9.1	1.63	1.85	2.166
10:08:00 AM	19.5	19.3	7.70	9.1	1.40	1.62	1.861
10:08:30 AM	19.5	19.3	7.89	9.1	1.21	1.43	1.608
10:09:00 AM	19.5	19.3	8.05	9.2	1.15	1.27	1.528
10:09:30 AM	19.5	19.3	8.23	9.2	0.97	1.09	1.289
10:10:00 AM	19.5	19.3	8.36	9.2	0.84	0.96	1.116
10:10:30 AM	19.5	19.3	8.45	9.2	0.75	0.87	0.997
10:11:00 AM	19.5	19.3	8.52	9.2	0.68	0.80	0.904

45.7 cm lift_Trial 2_10/1/2008

Air-lift	**20.3**	**cm**	$Q_{L,ave}$	**928.76**	**l min^{-1}**
Salinity	**33**	**ppt**	$Q_{G,ave}$	**1415.59**	**l min^{-1}**
C_s'	**9.2**	**mg l^{-1}**	Q_G:Q_L	**1.52**	

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		C_{out} - C_t	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
10:49:28 AM	19.5	19.4	9.03	9.2	0.17	0.17	0.227
10:49:59 AM	19.5	19.4	9.03	9.2	0.17	0.17	0.227
10:50:29 AM	19.5	19.4	9.02	9.2	0.18	0.18	0.241
10:50:59 AM	19.5	19.4	9.02	9.2	0.18	0.18	0.241
10:51:29 AM	19.5	19.4	9.01	9.2	0.19	0.19	0.254
10:51:59 AM	19.5	19.4	9.00	9.2	0.20	0.20	0.267
10:52:29 AM	19.5	19.4	8.90	9.2	0.30	0.30	0.401
10:52:59 AM	19.5	19.4	8.72	9.1	0.38	0.48	0.508
10:53:29 AM	19.5	19.4	8.48	9.0	0.52	0.72	0.695
10:53:59 AM	19.5	19.4	8.24	9.0	0.76	0.96	1.016
10:54:29 AM	19.5	19.4	8.01	8.9	0.89	1.19	1.190
10:54:59 AM	19.5	19.4	7.78	9.0	1.22	1.42	1.632
10:55:29 AM	19.5	19.4	7.59	9.0	1.41	1.61	1.886
10:55:59 AM	19.5	19.4	7.40	9.0	1.60	1.80	2.140
10:56:29 AM	19.5	19.4	7.23	8.9	1.67	1.97	2.233
10:56:59 AM	19.5	19.4	7.14	8.9	1.76	2.06	2.354
10:57:29 AM	19.5	19.4	7.05	8.9	1.85	2.15	2.474
10:57:59 AM	19.5	19.4	6.99	8.9	1.91	2.21	2.554
10:58:29 AM	19.5	19.4	6.90	8.9	2.00	2.30	2.675
10:58:59 AM	19.5	19.4	6.82	8.9	2.08	2.38	2.782
10:59:29 AM	19.5	19.4	6.66	8.8	2.14	2.54	2.862
10:59:59 AM	19.5	19.4	6.45	8.8	2.35	2.75	3.143
11:00:29 AM	19.5	19.4	6.30	8.8	2.50	2.90	3.344
11:00:59 AM	19.5	19.4	6.15	8.7	2.55	3.05	3.410
11:01:29 AM	19.5	19.4	5.98	8.7	2.72	3.22	3.638
11:01:59 AM	19.5	19.4	5.84	8.7	2.86	3.36	3.825
11:02:29 AM	19.6	19.4	5.73	8.7	2.97	3.47	3.972
11:02:59 AM	19.6	19.4	5.59	8.7	3.11	3.61	4.159
11:03:29 AM	19.6	19.4	5.48	8.8	3.32	3.72	4.440
11:03:59 AM	19.6	19.4	5.67	8.9	3.23	3.53	4.320
11:04:29 AM	19.6	19.5	6.00	9.0	3.00	3.20	4.012

45.7 cm lift_Trial 2_10/1/2008 (continued)

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		$C_{out} - C_t$	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
11:04:59 AM	19.6	19.5	6.36	9.0	2.64	2.84	3.531
11:05:29 AM	19.6	19.5	6.65	9.1	2.45	2.55	3.277
11:05:59 AM	19.6	19.5	6.90	9.1	2.20	2.30	2.942
11:06:29 AM	19.6	19.5	7.14	9.1	1.96	2.06	2.621
11:06:59 AM	19.6	19.5	7.38	9.2	1.82	1.82	2.434
11:07:29 AM	19.6	19.5	7.57	9.2	1.63	1.63	2.180
11:07:59 AM	19.6	19.5	7.77	9.2	1.43	1.43	1.913
11:08:29 AM	19.7	19.5	7.93	9.2	1.27	1.27	1.699
11:08:59 AM	19.7	19.5	8.07	9.2	1.13	1.13	1.511
11:09:29 AM	19.7	19.5	8.16	9.2	1.04	1.04	1.391
11:09:59 AM	19.7	19.5	8.25	9.2	0.95	0.95	1.271

OTR and $C_{deficit}$ Linear Regression Summary for 20.3 cm air-lift at 1,415 l min^{-1} air

Lift [cm]	Trial	OTR Coefficient for $C_{deficit}$ equations	R^2
38.1	1	$OTR = 1.3312*C_{deficit}$	0.973
38.1	2	$OTR = 1.3170*C_{deficit}$	0.982
45.7	1	$OTR = 1.0442*C_{deficit}$	0.991
45.7	2	$OTR = 1.1860*C_{deficit}$	0.984

DEGASSING STUDIES

CARBON DIOXIDE CALCULATIONS

Carbon dioxide was calculated from thermodynamic data, alkalinity and pH:

$$CO_2 = \left[\left(\frac{Alk * \left[H^+ \right]^2}{K_1 * \left(\left[H^+ \right] + 2 K_2 \right)} \right) * 44.01 * \frac{p_{sw}}{1000} \right] * 1000$$

Where: K_1 is the first acid dissociation constant
K_2 is the second acid dissociation constant
44.01 is the formula weight of carbon dioxide in g mol^{-1}
p_{sw} is density of seawater in kg m^{-3}
CO_2 is carbon dioxide concentration in mg l^{-1}
H^+ is 10^{-pH}

K1 and K2 were calculated from equations seen in Lueker et al. (2000):

$$K_1 = -\left(\frac{3633.86}{T} - 61.2172 + 9.6777 \ln T - 0.011555 * S + 0.0001152 * S^2 \right)$$

$$K_2 = -\left(\frac{471.78}{T} + 25.9290 - 3.16967 \ln T - 0.01786 * S + 0.0001122 * S^2 \right)$$

Where: S is salinity and T is temperature in degrees Kelvin

DEGASSING STUDIES (continued)

CARBON DIOXIDE CALCULATIONS

p_{sw} was determined from the one atmosphere international equation of state of seawater presented in Schetz and Fuhs (1999), valid for salinities between 0-42 and temperatures -2 to 40°C:

$$p_{sw} = dSMOW + a * S + b * (S)^{1.5} + c * (S)^{2}$$

Where:

$$dSMOW = 999.843 + 0.06794 * T - 0.0091 * (T^{2}) + 1.0017\ E-4 * (T^{3}) - 1.1201\ E-6 * (T^{4}) + 6.5363\ E-9 * (T^{5})$$

$$a = 0.824493 - 0.00409 * T + 7.6438\ E-5 * (T^{2}) - 8.2467\ E-7 * (T^{3}) + 5.3875\ E-9 * (T^{4})$$

$$b = -0.005725 + 1.0227\ E-4 * T - 1.6546\ E-6 * (T^{2})$$

$$c = 0.00048314$$

And: dSMOW is the density of the standard mean ocean water
T is temperature in degrees Celsius
S is salinity in ppt

DEGASSING STUDIES (continued)

20.3 cm air-lift, 850 l air min^{-1}

30.5 cm lift_Trial 1_10/1/2008

Air-lift	20.3	cm	$Q_{L,ave}$	912.12	l min^{-1}	dSMOW	998.30
Salinity	33	ppt	$Q_{G,ave}$	849.35	l min^{-1}	a	0.77
C_s	0.5	mg l^{-1}	Q_G:Q_L	0.93		b	-0.0044
FW_{CO2}	44.01	g mol^{-1}	Alkalinity	116.36	mg $CaCO_3$ l^{-1}	c	0.0005
						p_{sw}	1023.36

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		C_t - C_{out}	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
1:13:00 PM	19.5	19.5	7.50	7.58	2.46	2.03	0.43	1.96	0.571
1:13:31 PM	19.5	19.5	7.50	7.58	2.46	2.03	0.43	1.96	0.571
1:14:01 PM	19.5	19.5	7.50	7.58	2.46	2.03	0.43	1.96	0.571
1:14:31 PM	19.5	19.5	7.50	7.58	2.46	2.03	0.43	1.96	0.571
1:15:01 PM	19.5	19.5	7.50	7.58	2.46	2.03	0.43	1.96	0.571
1:15:31 PM	19.5	19.5	7.50	7.58	2.46	2.03	0.43	1.96	0.571
1:16:01 PM	19.5	19.5	7.44	7.57	2.84	2.08	0.77	2.34	1.009
1:16:30 PM	19.5	19.5	7.23	7.41	4.69	3.06	1.64	4.19	2.149
1:17:00 PM	19.5	19.5	6.95	7.19	9.06	5.16	3.90	8.56	5.129
1:17:30 PM	19.5	19.5	6.67	6.93	17.39	9.50	7.90	16.89	10.371
1:18:01 PM	19.5	19.5	6.51	6.76	25.20	14.11	11.09	24.70	14.566
1:18:31 PM	19.6	19.5	6.35	6.63	36.41	19.09	17.33	35.91	22.757
1:19:01 PM	19.6	19.5	6.25	6.51	45.87	25.20	20.67	45.37	27.151
1:19:31 PM	19.6	19.5	6.16	6.43	56.47	30.33	26.14	55.97	34.336
1:20:01 PM	19.6	19.5	6.08	6.36	67.92	35.66	32.26	67.42	42.376
1:20:31 PM	19.6	19.5	6.03	6.30	76.22	40.96	35.26	75.72	46.318
1:21:01 PM	19.6	19.5	6.07	6.32	69.50	39.11	30.39	69.00	39.922
1:21:31 PM	19.6	19.4	6.13	6.37	60.52	34.92	25.60	60.02	33.625
1:22:01 PM	19.6	19.5	6.20	6.45	51.49	28.96	22.53	50.99	29.594
1:22:31 PM	19.6	19.5	6.32	6.54	39.02	23.51	15.51	38.52	20.376
1:23:01 PM	19.6	19.5	6.42	6.65	30.97	18.22	12.75	30.47	16.747
1:23:30 PM	19.6	19.5	6.54	6.76	23.46	14.11	9.35	22.96	12.277
1:24:00 PM	19.6	19.5	6.69	6.87	16.57	10.92	5.64	16.07	7.413
1:24:30 PM	19.6	19.5	6.81	6.96	12.54	8.85	3.68	12.04	4.835
1:25:00 PM	19.6	19.5	6.91	7.04	9.93	7.34	2.59	9.43	3.398

30.5 cm lift_Trial 1_10/1/2008 (continued)

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		$C_t - C_{out}$	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
1:25:30 PM	19.6	19.5	7.00	7.10	8.05	6.38	1.67	7.55	2.191
1:26:00 PM	19.6	19.5	7.07	7.15	6.83	5.67	1.16	6.33	1.522
1:26:30 PM	19.6	19.5	7.13	7.18	5.93	5.28	0.65	5.43	0.850
1:27:00 PM	19.6	19.5	7.17	7.23	5.40	4.69	0.70	4.90	0.923
1:27:30 PM	19.6	19.5	7.23	7.27	4.68	4.27	0.41	4.18	0.544
1:28:01 PM	19.6	19.5	7.26	7.30	4.36	3.98	0.39	3.86	0.507
1:28:31 PM	19.6	19.5	7.30	7.34	3.97	3.61	0.35	3.47	0.463
1:29:01 PM	19.6	19.5	7.32	7.37	3.78	3.36	0.42	3.28	0.549
1:29:31 PM	19.6	19.5	7.34	7.39	3.61	3.21	0.40	3.11	0.524
1:30:01 PM	19.6	19.5	7.36	7.40	3.44	3.13	0.31	2.94	0.403
1:30:31 PM	19.6	19.5	7.36	7.42	3.44	2.98	0.45	2.94	0.595
1:31:01 PM	19.6	19.4	7.37	7.43	3.36	2.92	0.44	2.86	0.573
1:31:31 PM	19.6	19.4	7.37	7.44	3.36	2.85	0.51	2.86	0.664
1:32:01 PM	19.6	19.4	7.38	7.44	3.28	2.85	0.43	2.78	0.560

30.5 cm lift_Trial 2_10/1/2008

Air-lift	20.3	cm	$Q_{L,ave}$	908.34	l min^{-1}	dSMOW	998.30
Salinity	33	ppt	$Q_{G,ave}$	849.35	l min^{-1}	a	0.77
C_s	0.5	mg l^{-1}	Q_G:Q_L	0.94		b	-0.0044
FW_{CO2}	44.01	g mol^{-1}	Alkalinity	116.36	mg $CaCO_3$ l^{-1}	c	0.0005
						p_{sw}	1023.35

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		$C_t - C_{out}$	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
1:55:11 PM	19.6	19.5	7.41	7.49	3.05	2.52	0.53	2.55	0.691
1:55:42 PM	19.6	19.5	7.41	7.50	3.05	2.46	0.59	2.55	0.770
1:56:12 PM	19.6	19.5	7.41	7.50	3.05	2.46	0.59	2.55	0.770
1:56:42 PM	19.6	19.5	7.39	7.49	3.20	2.52	0.68	2.70	0.887
1:57:12 PM	19.6	19.5	7.19	7.35	5.15	3.53	1.62	4.65	2.117
1:57:42 PM	19.6	19.5	6.95	7.15	9.04	5.67	3.37	8.54	4.413
1:58:12 PM	19.6	19.5	6.69	6.92	16.57	9.72	6.85	16.07	8.955
1:58:42 PM	19.6	19.5	6.48	6.72	26.96	15.49	11.47	26.46	15.001
1:59:12 PM	19.6	19.5	6.31	6.58	39.94	21.43	18.51	39.44	24.207

30.5 cm lift_Trial 2_10/1/2008 (continued)

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		$C_t - C_{out}$	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
1:59:42 PM	19.6	19.5	6.20	6.46	51.49	28.29	23.19	50.99	30.338
2:00:12 PM	19.6	19.5	6.12	6.38	61.93	34.04	27.89	61.43	36.474
2:00:42 PM	19.6	19.5	6.04	6.32	74.48	39.11	35.38	73.98	46.271
2:01:12 PM	19.6	19.5	5.98	6.26	85.54	44.92	40.62	85.04	53.127
2:01:42 PM	19.6	19.5	5.97	6.23	87.54	48.15	39.39	87.04	51.522
2:02:12 PM	19.6	19.5	5.98	6.23	85.54	48.15	37.39	85.04	48.911
2:02:42 PM	19.6	19.5	6.03	6.28	76.22	42.90	33.33	75.72	43.592
2:03:12 PM	19.6	19.5	6.11	6.36	63.38	35.66	27.72	62.88	36.258
2:03:42 PM	19.6	19.5	6.21	6.45	50.31	28.96	21.36	49.81	27.935
2:04:12 PM	19.6	19.5	6.32	6.55	39.02	22.97	16.05	38.52	20.996
2:04:42 PM	19.6	19.5	6.43	6.64	30.26	18.65	11.61	29.76	15.192
2:05:12 PM	19.6	19.5	6.56	6.75	22.40	14.44	7.95	21.90	10.403
2:05:42 PM	19.6	19.5	6.64	6.83	18.61	11.99	6.62	18.11	8.653
2:06:12 PM	19.6	19.5	6.76	6.90	14.08	10.19	3.90	13.58	5.095
2:06:42 PM	19.6	19.5	6.84	6.96	11.69	8.85	2.84	11.19	3.709
2:07:12 PM	19.6	19.5	6.93	7.03	9.48	7.52	1.96	8.98	2.564
2:07:42 PM	19.6	19.5	7.01	7.09	7.86	6.53	1.33	7.36	1.740
2:08:12 PM	19.6	19.5	7.08	7.16	6.67	5.54	1.13	6.17	1.481
2:08:42 PM	19.6	19.5	7.11	7.20	6.22	5.04	1.18	5.72	1.539
2:09:12 PM	19.6	19.5	7.16	7.23	5.53	4.69	0.83	5.03	1.088
2:09:42 PM	19.6	19.5	7.19	7.26	5.15	4.37	0.78	4.65	1.015
2:10:12 PM	19.6	19.5	7.21	7.28	4.91	4.17	0.74	4.41	0.969
2:10:42 PM	19.6	19.5	7.23	7.31	4.68	3.88	0.80	4.18	1.048

38.1 cm lift_Trial 1_10/1/2008

Air-lift	**20.3**	**cm**	$Q_{L,ave}$	**787.92**	**l min^{-1}**	**dSMOW**	**998.29**
Salinity	**33**	**ppt**	$Q_{G,ave}$	**849.35**	**l min^{-1}**	**a**	**0.77**
C_s	**0.5**	**mg l^{-1}**	Q_G:Q_L	**1.08**		**b**	**-0.0044**
FW_{CO2}	**44.01**	**g mol^{-1}**	**Alkalinity**	**116.36**	**mg $CaCO_3$ l^{-1}**	**c**	**0.0005**
						p_{sw}	**1023.35**

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		C_t - C_{out}	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
2:56:14 PM	19.6	19.5	7.36	7.49	3.44	2.52	0.92	2.94	1.040
2:56:44 PM	19.6	19.5	7.36	7.50	3.44	2.46	0.98	2.94	1.108
2:57:14 PM	19.6	19.5	7.36	7.50	3.44	2.46	0.98	2.94	1.108
2:57:44 PM	19.6	19.5	7.34	7.49	3.61	2.52	1.08	3.11	1.230
2:58:14 PM	19.6	19.5	7.14	7.35	5.79	3.53	2.26	5.29	2.567
2:58:44 PM	19.6	19.5	6.90	7.15	10.16	5.67	4.49	9.66	5.099
2:59:14 PM	19.6	19.5	6.64	6.92	18.61	9.72	8.88	18.11	10.081
2:59:44 PM	19.6	19.5	6.43	6.72	30.26	15.49	14.77	29.76	16.763
3:00:14 PM	19.6	19.5	6.26	6.58	44.83	21.43	23.40	44.33	26.545
3:00:44 PM	19.6	19.5	6.15	6.46	57.79	28.29	29.49	57.29	33.463
3:01:14 PM	19.6	19.5	6.07	6.38	69.50	34.04	35.46	69.00	40.232
3:01:44 PM	19.6	19.5	5.99	6.32	83.59	39.11	44.48	83.09	50.468
3:02:14 PM	19.6	19.5	5.93	6.26	95.99	44.92	51.07	95.49	57.945
3:02:44 PM	19.6	19.5	5.95	6.23	91.67	48.15	43.52	91.17	49.379
3:03:14 PM	19.6	19.5	5.96	6.23	89.58	48.15	41.43	89.08	47.008
3:03:44 PM	19.6	19.5	5.98	6.30	85.54	40.96	44.58	85.04	50.582
3:04:14 PM	19.6	19.5	6.09	6.38	66.37	34.04	32.32	65.87	36.675
3:04:44 PM	19.6	19.5	6.19	6.47	52.69	27.65	25.04	52.19	28.414
3:05:14 PM	19.6	19.5	6.27	6.57	43.80	21.93	21.87	43.30	24.814
3:05:44 PM	19.6	19.6	6.38	6.66	33.97	17.76	16.21	33.47	18.390
3:06:14 PM	19.6	19.6	6.51	6.77	25.15	13.76	11.39	24.65	12.923
3:06:44 PM	19.6	19.6	6.59	6.85	20.89	11.42	9.47	20.39	10.748
3:07:14 PM	19.6	19.6	6.71	6.92	15.82	9.70	6.12	15.32	6.939
3:07:44 PM	19.6	19.6	6.79	6.98	13.13	8.43	4.70	12.63	5.334
3:08:14 PM	19.6	19.6	6.88	7.05	10.65	7.16	3.49	10.15	3.963
3:08:44 PM	19.6	19.6	6.96	7.08	8.84	6.67	2.17	8.34	2.457
3:09:14 PM	19.6	19.6	7.03	7.15	7.50	5.66	1.84	7.00	2.091
3:09:44 PM	19.6	19.6	7.06	7.19	6.99	5.15	1.84	6.49	2.091
3:10:14 PM	19.6	19.6	7.11	7.22	6.22	4.80	1.42	5.72	1.611
3:10:44 PM	19.6	19.6	7.14	7.25	5.79	4.47	1.33	5.29	1.504

38.1 cm lift_Trial 1_10/1/2008 (continued)

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		$C_t - C_{out}$	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
3:11:14 PM	19.6	19.6	7.16	7.27	5.53	4.26	1.27	5.03	1.436
3:11:44 PM	19.6	19.6	7.18	7.30	5.27	3.97	1.30	4.77	1.480
3:12:14 PM	19.6	19.6	7.22	7.33	4.78	3.74	1.04	4.28	1.183
3:12:44 PM	19.6	19.6	7.25	7.35	4.44	3.51	0.93	3.94	1.056
3:13:14 PM	19.6	19.6	7.28	7.38	4.13	3.30	0.83	3.63	0.940
3:13:44 PM	19.6	19.6	7.31	7.40	3.84	3.10	0.74	3.34	0.835
3:14:14 PM	19.6	19.6	7.34	7.43	3.57	2.91	0.65	3.07	0.739
3:14:44 PM	19.6	19.6	7.38	7.46	3.31	2.74	0.57	2.81	0.652
3:15:14 PM	19.6	19.6	7.41	7.48	3.08	2.57	0.51	2.58	0.573

38.1 cm lift_Trial 2_10/1/2008

Air-lift	20.3	cm	$Q_{L,ave}$	749.39	l min^{-1}	dSMOW	998.29
Salinity	33	ppt	$Q_{G,ave}$	849.35	l min^{-1}	a	0.77
C_s	0.5	mg l^{-1}	Q_G:Q_L	1.13		b	-0.0044
FW_{CO2}	44.01	g mol^{-1}	Alkalinity	116.36	mg $CaCO_3$ l^{-1}	c	0.0005
						p_{sw}	1023.34

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		$C_t - C_{out}$	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
3:52:25 PM	19.6	19.6	7.15	7.37	5.66	3.36	2.30	5.16	2.482
3:52:55 PM	19.6	19.6	7.14	7.37	5.79	3.36	2.43	5.29	2.628
3:53:25 PM	19.6	19.6	7.14	7.38	5.79	3.28	2.51	5.29	2.713
3:53:55 PM	19.6	19.6	7.12	7.36	6.07	3.44	2.63	5.57	2.841
3:54:25 PM	19.6	19.6	7.14	7.35	5.79	3.52	2.27	5.29	2.450
3:54:55 PM	19.6	19.6	6.88	7.13	10.65	5.93	4.72	10.15	5.093
3:55:25 PM	19.6	19.6	6.62	6.90	19.49	10.16	9.33	18.99	10.064
3:55:55 PM	19.6	19.6	6.41	6.70	31.69	16.19	15.51	31.19	16.733
3:56:25 PM	19.6	19.6	6.24	6.56	46.95	22.40	24.55	46.45	26.490
3:56:55 PM	19.6	19.6	6.13	6.44	60.52	29.57	30.95	60.02	33.396
3:57:25 PM	19.6	19.6	6.05	6.36	72.79	35.58	37.21	72.29	40.151
3:57:55 PM	19.6	19.6	5.97	6.30	87.54	40.87	46.67	87.04	50.358
3:58:25 PM	19.6	19.6	5.91	6.24	100.52	46.95	53.58	100.02	57.818
3:58:55 PM	19.6	19.6	5.90	6.21	102.87	50.31	52.56	102.37	56.715

38.1 cm lift_Trial 2_10/1/2008 (continued)

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		C_t - C_{out}	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
3:59:25 PM	19.6	19.6	5.95	6.21	91.67	50.31	41.35	91.17	44.626
3:59:55 PM	19.6	19.6	6.00	6.28	81.68	42.80	38.88	81.18	41.957
4:00:25 PM	19.6	19.6	6.11	6.36	63.38	35.58	27.80	62.88	29.997
4:00:55 PM	19.6	19.6	6.18	6.45	53.92	28.89	25.03	53.42	27.008
4:01:25 PM	19.6	19.6	6.23	6.55	48.04	22.92	25.12	47.54	27.107
4:01:55 PM	19.6	19.6	6.34	6.62	37.26	19.49	17.77	36.76	19.178
4:02:25 PM	19.6	19.6	6.47	6.73	27.59	15.10	12.49	27.09	13.476
4:02:55 PM	19.6	19.6	6.55	6.81	22.92	12.54	10.39	22.42	11.209
4:03:25 PM	19.6	19.6	6.67	6.88	17.36	10.65	6.71	16.86	7.237
4:03:55 PM	19.6	19.6	6.75	6.94	14.41	9.26	5.16	13.91	5.563
4:04:25 PM	19.6	19.5	6.84	7.01	11.69	7.88	3.81	11.19	4.114
4:04:55 PM	19.6	19.5	6.92	7.04	9.70	7.34	2.36	9.20	2.545
4:05:25 PM	19.6	19.5	6.99	7.11	8.24	6.23	2.01	7.74	2.166
4:05:55 PM	19.6	19.5	7.02	7.15	7.68	5.67	2.01	7.18	2.167
4:06:25 PM	19.6	19.5	7.07	7.18	6.83	5.28	1.55	6.33	1.668
4:06:55 PM	19.6	19.5	7.10	7.21	6.36	4.92	1.44	5.86	1.556
4:07:25 PM	19.6	19.5	7.12	7.23	6.07	4.69	1.38	5.57	1.486

45.7 cm_Trial 1_10/2/2008

Air-lift	20.3	cm	$Q_{L,ave}$	663.96	l min^{-1}	dSMOW	998.31
Salinity	33	ppt	$Q_{G,ave}$	849.35	l min^{-1}	a	0.77
C_s	0.5	mg l^{-1}	Q_G:Q_L	1.28		b	-0.0044
FW_{CO2}	44.01	g mol^{-1}	Alkalinity	116.36	mg $CaCO_3$ l^{-1}	c	0.0005
						p_{sw}	1023.37

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		C_t - C_{out}	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
7:38:48 AM	19.5	19.5	7.70	7.68	1.51	1.59	-0.08	1.01	-0.073
7:39:18 AM	19.5	19.5	7.70	7.68	1.51	1.59	-0.08	1.01	-0.073
7:39:48 AM	19.5	19.5	7.70	7.68	1.51	1.59	-0.08	1.01	-0.073
7:40:18 AM	19.5	19.5	7.70	7.68	1.51	1.59	-0.08	1.01	-0.073
7:40:48 AM	19.5	19.5	7.70	7.68	1.51	1.59	-0.08	1.01	-0.073
7:41:19 AM	19.5	19.5	7.69	7.68	1.55	1.59	-0.04	1.05	-0.037

45.7 cm_Trial 1_10/2/2008 (continued)

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		$C_t - C_{out}$	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
7:41:48 AM	19.5	19.5	7.44	7.62	2.84	1.84	1.01	2.34	0.963
7:42:19 AM	19.5	19.5	7.28	7.47	4.17	2.65	1.52	3.67	1.456
7:42:48 AM	19.5	19.5	6.94	7.29	9.28	4.07	5.21	8.78	4.978
7:43:28 AM	19.5	19.5	6.54	7.02	23.51	7.69	15.82	23.01	15.122
7:43:58 AM	19.5	19.5	6.44	6.84	29.63	11.72	17.92	29.13	17.132
7:44:28 AM	19.5	19.5	6.36	6.74	35.66	14.78	20.87	35.16	19.956
7:44:58 AM	19.5	19.5	6.26	6.64	44.92	18.65	26.28	44.42	25.123
7:45:28 AM	19.5	19.5	6.16	6.54	56.59	23.51	33.08	56.09	31.628
7:45:59 AM	19.5	19.5	6.08	6.44	68.07	29.63	38.43	67.57	36.745
7:46:29 AM	19.5	19.5	6.07	6.38	69.66	34.05	35.61	69.16	34.047
7:46:59 AM	19.5	19.5	6.10	6.35	65.00	36.49	28.51	64.50	27.255
7:47:28 AM	19.5	19.5	6.18	6.36	54.04	35.66	18.38	53.54	17.575
7:47:58 AM	19.5	19.5	6.26	6.42	44.92	31.04	13.89	44.42	13.277
7:48:28 AM	19.5	19.5	6.36	6.49	35.66	26.40	9.26	35.16	8.853
7:48:58 AM	19.5	19.5	6.45	6.56	28.96	22.45	6.51	28.46	6.224
7:49:28 AM	19.5	19.5	6.54	6.63	23.51	19.09	4.43	23.01	4.232
7:49:58 AM	19.5	19.5	6.63	6.70	19.09	16.22	2.86	18.59	2.736
7:50:28 AM	19.5	19.5	6.74	6.77	14.78	13.79	1.00	14.28	0.952
7:50:58 AM	19.5	19.5	6.81	6.84	12.56	11.72	0.85	12.06	0.810
7:51:28 AM	19.5	19.5	6.88	6.90	10.67	10.19	0.49	10.17	0.465
7:51:58 AM	19.5	19.5	7.00	6.96	8.06	8.85	-0.79	7.56	-0.756
7:52:28 AM	19.5	19.5	7.07	7.02	6.84	7.69	-0.85	6.34	-0.814
7:52:58 AM	19.5	19.5	7.12	7.07	6.08	6.84	-0.76	5.58	-0.725

45.7 cm lift_Trial 2_10/2/2008

Air-lift	**20.3**	**cm**	$Q_{L,ave}$	**644.12**	**l min^{-1}**	**dSMOW**	**998.31**
Salinity	**33**	**ppt**	$Q_{G,ave}$	**849.35**	**l min^{-1}**	**a**	**0.77**
C_s	**0.5**	**mg l^{-1}**	Q_G:Q_L	**1.32**		**b**	**-0.0044**
FW_{CO2}	**44.01**	**g mol^{-1}**	**Alkalinity**	**116.36**	**mg $CaCO_3$ l^{-1}**	**c**	**0.0005**
						p_{sw}	**1023.37**

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		C_t - C_{out}	$C_{deficit}$	CTR
Time	**Inlet**	**Outlet**	**Inlet**	**Outlet**	**Inlet**	**Outlet**	**[mg l^{-1}]**	**[mg l^{-1}]**	**[kg CO_2 day^{-1}]**
8:14:31 AM	19.5	19.5	7.62	7.57	1.84	2.08	-0.24	1.34	-0.222
8:15:02 AM	19.5	19.5	7.62	7.57	1.84	2.08	-0.24	1.34	-0.222
8:15:32 AM	19.4	19.5	7.62	7.57	1.84	2.08	-0.23	1.34	-0.218
8:16:02 AM	19.5	19.5	7.61	7.58	1.88	2.03	-0.14	1.38	-0.133
8:16:32 AM	19.5	19.5	7.58	7.57	2.03	2.08	-0.05	1.53	-0.046
8:17:02 AM	19.4	19.5	7.41	7.54	3.06	2.23	0.83	2.56	0.770
8:17:32 AM	19.5	19.5	7.07	7.42	6.84	2.98	3.86	6.34	3.579
8:18:02 AM	19.5	19.5	6.74	7.15	14.78	5.67	9.11	14.28	8.454
8:18:32 AM	19.5	19.5	6.45	6.94	28.96	9.28	19.68	28.46	18.252
8:19:02 AM	19.5	19.5	6.30	6.75	40.96	14.44	26.51	40.46	24.593
8:19:32 AM	19.5	19.5	6.17	6.59	55.30	20.94	34.36	54.80	31.871
8:20:02 AM	19.5	19.5	6.09	6.47	66.51	27.65	38.87	66.01	36.050
8:20:32 AM	19.5	19.5	5.97	6.36	87.73	35.66	52.07	87.23	48.297
8:21:02 AM	19.5	19.5	5.99	6.28	83.77	42.90	40.88	83.27	37.913
8:21:32 AM	19.5	19.5	6.05	6.26	72.94	44.92	28.02	72.44	25.990
8:22:02 AM	19.5	19.5	6.10	6.29	65.00	41.92	23.08	64.50	21.408
8:22:32 AM	19.5	19.5	6.19	6.34	52.81	37.34	15.46	52.31	14.342
8:23:02 AM	19.5	19.5	6.29	6.42	41.92	31.04	10.88	41.42	10.091
8:23:32 AM	19.5	19.5	6.38	6.49	34.05	26.40	7.65	33.55	7.094
8:24:02 AM	19.5	19.5	6.48	6.57	27.01	21.93	5.08	26.51	4.714
8:24:32 AM	19.5	19.5	6.57	6.65	21.93	18.22	3.71	21.43	3.444
8:25:02 AM	19.5	19.5	6.63	6.72	19.09	15.49	3.60	18.59	3.337
8:25:32 AM	19.5	19.5	6.76	6.79	14.11	13.16	0.95	13.61	0.882
8:26:02 AM	19.5	19.5	6.82	6.85	12.27	11.45	0.83	11.77	0.768
8:26:32 AM	19.5	19.5	6.86	6.91	11.18	9.95	1.23	10.68	1.142
8:27:02 AM	19.5	19.5	6.97	6.97	8.65	8.65	0.00	8.15	0.000
8:27:32 AM	19.5	19.5	7.03	7.02	7.52	7.69	-0.18	7.02	-0.165

CTR and $C_{deficit}$ Linear Regression Summary for 20.3 cm air-lift at 850 l min^{-1} air

Lift [cm]	Trial	CTR Coefficient for $C_{deficit}$ equations	R^2
30.5	1	$CTR = 0.5822*C_{deficit}$	0.988
30.5	2	$CTR = 0.5800*C_{deficit}$	0.991
38.1	1	$CTR = 0.5698*C_{deficit}$	0.992
38.1	2	$CTR = 0.5388*C_{deficit}$	0.989
45.7	1	$CTR = 0.4494*C_{deficit}$	0.826
45.7	2	$CTR = 0.4363*C_{deficit}$	0.817

DEGASSING STUDIES (continued)

20.3 cm air-lift, 1,132 l air min^{-1}

38.1 cm lift_Trial 1_9/29/2008

Air-lift	20.3	cm	$Q_{L,ave}$	996.54	l min^{-1}	dSMOW	998.27
Salinity	33	ppt	$Q_{G,ave}$	1132.47	l min^{-1}	a	0.77
C_s	0.5	mg l^{-1}	Q_G:Q_L	1.14		b	-0.0044
FW_{CO2}	44.01	g mol^{-1}	Alkalinity	115.11	mg $CaCO_3$ l^{-1}	c	0.0005
						p_{sw}	1023.32

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		C_t - C_{out}	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
2:41:52 PM	19.7	19.7	7.66	7.77	1.64	1.25	0.39	1.14	0.564
2:42:23 PM	19.7	19.7	7.66	7.77	1.64	1.25	0.39	1.14	0.564
2:42:53 PM	19.7	19.7	7.66	7.77	1.64	1.25	0.39	1.14	0.564
2:43:23 PM	19.7	19.7	7.66	7.77	1.64	1.25	0.39	1.14	0.564
2:43:53 PM	19.7	19.7	7.66	7.77	1.64	1.25	0.39	1.14	0.564
2:44:23 PM	19.7	19.7	7.66	7.77	1.64	1.25	0.39	1.14	0.564
2:44:53 PM	19.7	19.7	7.66	7.77	1.64	1.25	0.39	1.14	0.564
2:45:23 PM	19.7	19.7	7.66	7.77	1.64	1.25	0.39	1.14	0.564
2:45:53 PM	19.7	19.7	7.66	7.77	1.64	1.25	0.39	1.14	0.564
2:46:23 PM	19.7	19.7	7.34	7.47	3.56	2.61	0.95	3.06	1.368
2:46:53 PM	19.7	19.7	7.12	7.34	5.99	3.56	2.43	5.49	3.492
2:47:23 PM	19.7	19.7	6.75	7.26	14.23	4.31	9.92	13.73	14.239
2:47:53 PM	19.7	19.7	6.62	7.15	19.24	5.58	13.66	18.74	19.597
2:48:23 PM	19.7	19.7	6.55	7.08	22.63	6.58	16.05	22.13	23.026
2:48:53 PM	19.7	19.7	6.44	6.92	29.19	9.58	19.62	28.69	28.149
2:49:23 PM	19.7	19.7	6.39	6.83	32.77	11.81	20.96	32.27	30.075
2:49:53 PM	19.7	19.7	6.36	6.75	35.12	14.23	20.90	34.62	29.985
2:50:23 PM	19.7	19.7	6.33	6.68	37.65	16.74	20.91	37.15	29.999
2:50:53 PM	19.7	19.7	6.31	6.64	39.43	18.37	21.06	38.93	30.218
2:51:23 PM	19.7	19.7	6.29	6.60	41.29	20.15	21.14	40.79	30.332
2:51:53 PM	19.7	19.7	6.28	6.57	42.26	21.60	20.65	41.76	29.634
2:52:23 PM	19.7	19.7	6.26	6.54	44.25	23.16	21.09	43.75	30.270
2:52:53 PM	19.7	19.7	6.25	6.51	45.29	24.83	20.46	44.79	29.363
2:53:23 PM	19.7	19.7	6.27	6.50	43.24	25.41	17.84	42.74	25.595
2:53:53 PM	19.7	19.7	6.38	6.49	33.54	26.00	7.53	33.04	10.812
2:54:23 PM	19.7	19.7	6.55	6.62	22.63	19.24	3.39	22.13	4.863

38.1 cm lift_Trial 1_9/29/2008 (continued)

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		$C_t - C_{out}$	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
2:54:53 PM	19.7	19.7	6.79	6.85	12.96	11.27	1.69	12.46	2.426
2:55:23 PM	19.7	19.7	6.89	6.97	10.27	8.52	1.75	9.77	2.512
2:55:53 PM	19.7	19.7	7.02	7.04	7.58	7.23	0.35	7.08	0.498
2:56:23 PM	19.7	19.7	7.11	7.11	6.14	6.14	0.00	5.64	0.000
2:56:53 PM	19.7	19.7	7.15	7.16	5.58	5.45	0.13	5.08	0.187
2:57:23 PM	19.7	19.7	7.20	7.21	4.96	4.85	0.12	4.46	0.166
2:57:53 PM	19.7	19.7	7.22	7.24	4.73	4.51	0.22	4.23	0.314
2:58:23 PM	19.7	19.7	7.23	7.27	4.62	4.20	0.42	4.12	0.600
2:58:53 PM	19.7	19.7	7.27	7.30	4.20	3.92	0.29	3.70	0.415
2:59:23 PM	19.7	19.7	7.27	7.27	4.20	4.20	0.00	3.70	0.000
2:59:53 PM	19.7	19.7	7.27	7.27	4.20	4.20	0.00	3.70	0.000
3:00:23 PM	19.7	19.7	7.58	7.64	2.00	1.72	0.27	1.50	0.392
3:00:53 PM	19.7	19.7	7.59	7.65	1.95	1.68	0.27	1.45	0.383
3:01:23 PM	19.7	19.7	7.59	7.66	1.95	1.64	0.31	1.45	0.442
3:01:53 PM	19.7	19.7	7.58	7.66	2.00	1.64	0.36	1.50	0.511
3:02:23 PM	19.7	19.7	7.59	7.67	1.95	1.60	0.35	1.45	0.499
3:02:53 PM	19.7	19.7	7.59	7.67	1.95	1.60	0.35	1.45	0.499
3:03:23 PM	19.7	19.7	7.59	7.67	1.95	1.60	0.35	1.45	0.499
3:03:53 PM	19.7	19.7	7.59	7.67	1.95	1.60	0.35	1.45	0.499
3:04:23 PM	19.7	19.7	7.59	7.68	1.95	1.56	0.39	1.45	0.555

38.1 cm lift_Trial 2_9/30/2008

Air-lift	20.3	cm	$Q_{L,ave}$	982.32	l min^{-1}	dSMOW	998.31
Salinity	33	ppt	$Q_{G,ave}$	1132.47	l min^{-1}	a	0.77
C_s	0.5	mg l^{-1}	Q_G:Q_L	1.15		b	-0.0044
FW_{CO2}	44.01	g mol^{-1}	Alkalinity	111.95	mg $CaCO_3$ l^{-1}	c	0.0005
						p_{sw}	1023.36

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		$C_t - C_{out}$	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
2:11:20 PM	19.6	19.4	7.41	7.45	2.94	2.68	0.26	2.44	0.363
2:11:51 PM	19.6	19.4	7.43	7.47	2.80	2.55	0.24	2.30	0.347
2:12:21 PM	19.6	19.4	7.43	7.48	2.80	2.49	0.31	2.30	0.433

38.1 cm lift_Trial 2_9/30/2008 (continued)

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		$C_t - C_{out}$	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
2:12:51 PM	19.6	19.4	7.44	7.49	2.73	2.43	0.30	2.23	0.423
2:13:21 PM	19.6	19.4	7.34	7.49	3.47	2.43	1.04	2.97	1.468
2:13:51 PM	19.6	19.4	7.06	7.35	6.73	3.40	3.32	6.23	4.700
2:14:21 PM	19.6	19.4	6.76	7.13	13.55	5.73	7.82	13.05	11.060
2:14:51 PM	19.6	19.4	6.52	6.87	23.64	10.54	13.11	23.14	18.544
2:15:21 PM	19.6	19.4	6.36	6.71	34.24	15.29	18.95	33.74	26.805
2:15:51 PM	19.6	19.4	6.29	6.63	40.25	18.40	21.84	39.75	30.897
2:16:21 PM	19.6	19.4	6.28	6.61	41.19	19.28	21.91	40.69	30.991
2:16:51 PM	19.6	19.4	6.32	6.62	37.55	18.84	18.72	37.05	26.474
2:17:21 PM	19.6	19.4	6.38	6.67	32.69	16.77	15.92	32.19	22.513
2:17:51 PM	19.6	19.4	6.48	6.74	25.94	14.26	11.68	25.44	16.524
2:18:21 PM	19.6	19.4	6.61	6.84	19.19	11.30	7.90	18.69	11.170
2:18:51 PM	19.6	19.4	6.73	6.93	14.53	9.16	5.37	14.03	7.595
2:19:21 PM	19.6	19.4	6.84	7.02	11.25	7.42	3.83	10.75	5.415
2:19:51 PM	19.6	19.5	6.94	7.09	8.91	6.28	2.63	8.41	3.714
2:20:21 PM	19.6	19.4	7.03	7.16	7.22	5.34	1.88	6.72	2.654
2:20:51 PM	19.6	19.5	7.11	7.22	5.98	4.62	1.36	5.48	1.919
2:21:21 PM	19.6	19.4	7.18	7.27	5.07	4.12	0.95	4.57	1.350
2:21:51 PM	19.6	19.4	7.24	7.32	4.40	3.66	0.74	3.90	1.054
2:22:21 PM	19.6	19.4	7.28	7.36	4.00	3.32	0.68	3.50	0.961
2:22:51 PM	19.6	19.4	7.31	7.36	3.73	3.32	0.40	3.23	0.571
2:23:21 PM	19.6	19.5	7.34	7.39	3.47	3.09	0.38	2.97	0.543
2:23:51 PM	19.6	19.5	7.36	7.42	3.31	2.87	0.44	2.81	0.617
2:24:21 PM	19.6	19.5	7.37	7.43	3.23	2.80	0.43	2.73	0.603
2:24:51 PM	19.6	19.4	7.39	7.43	3.08	2.81	0.27	2.58	0.380
2:25:21 PM	19.6	19.5	7.38	7.44	3.15	2.74	0.42	2.65	0.589

45.7 cm lift_Trial 1_9/29/2008

Air-lift	**20.3**	**cm**	**$Q_{L,ave}$**	**772.33**	**l min^{-1}**	**dSMOW**	**998.26**
Salinity	**33**	**ppt**	**$Q_{G,ave}$**	**1132.47**	**l min^{-1}**	**a**	**0.77**
C_s	**0.5**	**mg l^{-1}**	**Q_G:Q_L**	**1.47**		**b**	**-0.0044**
FW_{CO2}	**44.01**	**g mol^{-1}**	**Alkalinity**	**112.72**	**mg $CaCO_3$ l^{-1}**	**c**	**0.0005**
						p_{sw}	**1023.30**

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		C_t - C_{out}	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
4:06:53 PM	19.6	19.7	7.67	7.76	1.57	1.25	0.32	1.07	0.354
4:07:24 PM	19.6	19.7	7.69	7.77	1.49	1.22	0.27	0.99	0.304
4:07:54 PM	19.7	19.7	7.72	7.76	1.38	1.25	0.13	0.88	0.146
4:08:24 PM	19.7	19.7	7.72	7.77	1.38	1.22	0.16	0.88	0.181
4:08:54 PM	19.8	19.7	7.71	7.77	1.41	1.22	0.19	0.91	0.216
4:09:24 PM	19.8	19.7	7.69	7.77	1.49	1.22	0.27	0.99	0.296
4:09:54 PM	19.8	19.7	7.70	7.76	1.45	1.25	0.20	0.95	0.221
4:10:24 PM	19.8	19.7	7.71	7.72	1.41	1.38	0.03	0.91	0.035
4:10:54 PM	19.9	19.7	7.21	7.52	4.72	2.26	2.46	4.22	2.740
4:11:24 PM	19.9	19.7	7.02	7.26	7.39	4.22	3.17	6.89	3.528
4:11:54 PM	19.9	19.7	6.85	7.08	10.99	6.45	4.54	10.49	5.054
4:12:24 PM	20	19.7	6.52	6.93	23.60	9.16	14.44	23.10	16.057
4:12:54 PM	20	19.7	6.42	6.75	29.74	13.93	15.81	29.24	17.584
4:13:41 PM	19.8	19.7	6.30	6.70	39.42	15.65	23.77	38.92	26.439
4:14:12 PM	19.8	19.7	6.25	6.69	44.25	16.01	28.23	43.75	31.398
4:14:42 PM	19.8	19.7	6.35	6.76	35.12	13.61	21.51	34.62	23.920
4:15:12 PM	19.8	19.7	6.46	6.85	27.23	11.04	16.19	26.73	18.008
4:15:42 PM	19.8	19.7	6.58	6.94	20.62	8.95	11.68	20.12	12.986
4:16:12 PM	19.8	19.7	6.68	7.03	16.36	7.25	9.11	15.86	10.128
4:16:42 PM	19.8	19.7	6.78	7.10	12.96	6.15	6.81	12.46	7.578
4:17:12 PM	19.8	19.7	6.88	7.17	10.27	5.22	5.05	9.77	5.622
4:17:42 PM	19.8	19.7	7.01	7.23	7.58	4.53	3.05	7.08	3.396
4:18:12 PM	19.8	19.7	7.11	7.29	5.99	3.93	2.07	5.49	2.300
4:18:42 PM	19.8	19.7	7.12	7.32	5.85	3.66	2.20	5.35	2.446
4:19:12 PM	19.8	19.7	7.23	7.37	4.52	3.24	1.27	4.02	1.414
4:19:42 PM	19.8	19.7	7.29	7.41	3.92	2.95	0.97	3.42	1.078
4:20:12 PM	19.8	19.7	7.22	7.38	4.62	3.17	1.46	4.12	1.620
4:20:42 PM	19.8	19.7	7.17	7.38	5.20	3.17	2.04	4.70	2.265
4:21:12 PM	19.8	19.7	7.27	7.43	4.11	2.81	1.30	3.61	1.443
4:21:42 PM	19.8	19.7	7.32	7.49	3.65	2.43	1.22	3.15	1.352

45.7 cm lift_Trial 2_9/30/2008

Air-lift	**20.3**	**cm**	**$Q_{L,ave}$**	**746.93**	**l min^{-1}**	**dSMOW**	**998.29**
Salinity	**33**	**ppt**	**$Q_{G,ave}$**	**1132.47**	**l min^{-1}**	**a**	**0.77**
C_s	**0.5**	**mg l^{-1}**	**Q_G:Q_L**	**1.52**		**b**	**-0.0044**
FW_{CO2}	**44.01**	**g mol^{-1}**	**Alkalinity**	**111.95**	**mg $CaCO_3$ l^{-1}**	**c**	**0.0005**
						p_{sw}	**1023.34**

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		C_t - C_{out}	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
3:02:00 PM	19.6	19.6	7.43	7.52	2.80	2.25	0.55	2.30	0.588
3:02:31 PM	19.6	19.6	7.43	7.52	2.80	2.25	0.55	2.30	0.588
3:03:01 PM	19.6	19.6	7.43	7.52	2.80	2.25	0.55	2.30	0.588
3:03:31 PM	19.6	19.6	7.43	7.52	2.80	2.25	0.55	2.30	0.588
3:04:01 PM	19.6	19.6	7.43	7.52	2.80	2.25	0.55	2.30	0.588
3:04:31 PM	19.6	19.6	7.43	7.52	2.80	2.25	0.55	2.30	0.588
3:05:01 PM	19.6	19.6	7.33	7.51	3.55	2.31	1.25	3.05	1.342
3:05:31 PM	19.6	19.6	7.12	7.40	5.84	3.01	2.84	5.34	3.050
3:06:01 PM	19.6	19.6	6.86	7.22	10.74	4.61	6.12	10.24	6.585
3:06:31 PM	19.6	19.6	6.66	7.02	17.09	7.39	9.70	16.59	10.438
3:07:01 PM	19.6	19.6	6.50	6.92	24.76	9.33	15.43	24.26	16.597
3:07:31 PM	19.6	19.6	6.30	6.73	39.33	14.53	24.80	38.83	26.673
3:08:01 PM	19.6	19.6	6.20	6.61	49.54	19.19	30.35	49.04	32.644
3:08:31 PM	19.6	19.6	6.14	6.53	56.90	23.10	33.80	56.40	36.356
3:09:01 PM	19.6	19.6	6.15	6.50	55.61	24.76	30.84	55.11	33.172
3:09:31 PM	19.6	19.6	6.22	6.54	47.31	22.57	24.73	46.81	26.604
3:10:01 PM	19.6	19.6	6.33	6.62	36.69	18.75	17.94	36.19	19.295
3:10:31 PM	19.6	19.6	6.42	6.71	29.80	15.22	14.58	29.30	15.683
3:11:01 PM	19.6	19.6	6.51	6.79	24.20	12.64	11.56	23.70	12.435
3:11:31 PM	19.6	19.6	6.58	6.84	20.58	11.25	9.33	20.08	10.033
3:12:01 PM	19.6	19.6	6.68	6.90	16.32	9.78	6.54	15.82	7.031
3:12:31 PM	19.6	19.6	6.74	6.95	14.19	8.70	5.49	13.69	5.907
3:13:01 PM	19.6	19.6	6.80	7.00	12.35	7.74	4.60	11.85	4.952
3:13:31 PM	19.6	19.6	6.90	7.04	9.78	7.05	2.73	9.28	2.937
3:14:01 PM	19.6	19.6	6.94	7.08	8.91	6.42	2.49	8.41	2.679
3:14:31 PM	19.6	19.6	7.00	7.11	7.74	5.98	1.76	7.24	1.894
3:15:01 PM	19.6	19.6	7.05	7.15	6.89	5.44	1.44	6.39	1.552
3:15:31 PM	19.6	19.6	7.09	7.18	6.27	5.07	1.20	5.77	1.288
3:16:01 PM	19.6	19.6	7.15	7.21	5.44	4.72	0.72	4.94	0.773
3:16:31 PM	19.6	19.6	7.19	7.24	4.95	4.40	0.55	4.45	0.594

CTR and $C_{deficit}$ Linear Regression Summary for 20.3 cm air-lift at 1,132 l min^{-1} air

Lift [cm]	Trial	CTR Coefficient for $C_{deficit}$ equations	R^2
38.1	1	$CTR = 0.7580*C_{deficit}$	0.890
38.1	2	$CTR = 0.7133*C_{deficit}$	0.972
45.7	1	$CTR = 0.6664*C_{deficit}$	0.986
45.7	2	$CTR = 0.6002*C_{deficit}$	0.967

DEGASSING STUDIES (continued)

20.3 cm air-lift, 1,415 l air min^{-1}

38.1 cm lift_Trial 1_9/30/2008

Air-lift	20.3	cm	$Q_{L,ave}$	1136.11	l min^{-1}	dSMOW	998.27
Salinity	33	ppt	$Q_{G,ave}$	1415.59	l min^{-1}	a	0.77
C_s	0.5	mg l^{-1}	Q_G:Q_L	1.25		b	-0.0044
FW_{CO2}	44.01	g mol^{-1}	Alkalinity	111.95	mg $CaCO_3$ l^{-1}	c	0.0005
						p_{sw}	1023.32

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		C_t - C_{out}	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
4:43:39 PM	19.7	19.7	7.42	7.50	2.86	2.36	0.50	2.36	0.820
4:44:10 PM	19.7	19.7	7.42	7.50	2.86	2.36	0.50	2.36	0.820
4:44:40 PM	19.7	19.7	7.42	7.50	2.86	2.36	0.50	2.36	0.820
4:45:10 PM	19.7	19.7	7.26	7.47	4.19	2.53	1.65	3.69	2.704
4:45:40 PM	19.7	19.7	6.97	7.22	8.29	4.60	3.68	7.79	6.025
4:46:10 PM	19.7	19.7	6.72	7.06	14.84	6.71	8.13	14.34	13.294
4:46:40 PM	19.7	19.7	6.50	6.86	24.71	10.71	14.00	24.21	22.901
4:47:10 PM	19.7	19.7	6.37	6.71	33.38	15.19	18.19	32.88	29.765
4:47:40 PM	19.7	19.7	6.27	6.61	42.06	19.15	22.91	41.56	37.473
4:48:10 PM	19.7	19.7	6.21	6.53	48.31	23.05	25.26	47.81	41.318
4:48:40 PM	19.7	19.7	6.17	6.53	52.98	23.05	29.93	52.48	48.964
4:49:10 PM	19.7	19.7	6.25	6.58	44.05	20.53	23.51	43.55	38.470
4:49:40 PM	19.7	19.7	6.42	6.67	29.74	16.66	13.07	29.24	21.385
4:50:10 PM	19.7	19.7	6.54	6.76	22.52	13.52	9.00	22.02	14.731
4:50:40 PM	19.7	19.7	6.65	6.86	17.46	10.71	6.74	16.96	11.031
4:51:10 PM	19.7	19.7	6.78	6.96	12.91	8.48	4.42	12.41	7.236
4:51:40 PM	19.7	19.7	6.91	7.05	9.53	6.87	2.66	9.03	4.356
4:52:10 PM	19.7	19.7	7.02	7.13	7.37	5.69	1.68	6.87	2.745
4:52:40 PM	19.7	19.7	7.10	7.20	6.11	4.83	1.28	5.61	2.099
4:53:10 PM	19.7	19.7	7.17	7.25	5.18	4.29	0.89	4.68	1.461
4:53:40 PM	19.7	19.7	7.21	7.29	4.71	3.90	0.81	4.21	1.332
4:54:10 PM	19.7	19.7	7.25	7.32	4.29	3.63	0.66	3.79	1.075
4:54:40 PM	19.7	19.7	7.27	7.35	4.09	3.38	0.71	3.59	1.160
4:55:10 PM	19.7	19.7	7.30	7.37	3.81	3.22	0.59	3.31	0.958
4:55:40 PM	19.7	19.7	7.32	7.39	3.63	3.07	0.56	3.13	0.914
4:56:10 PM	19.7	19.7	7.33	7.40	3.55	3.00	0.55	3.05	0.894

38.1 cm lift_Trial 1_9/30/2008 (continued)

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		$C_t - C_{out}$	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
4:56:40 PM	19.7	19.7	7.33	7.40	3.55	3.00	0.55	3.05	0.894
4:57:10 PM	19.7	19.7	7.34	7.41	3.46	2.93	0.53	2.96	0.873

38.1 cm lift_Trial 2_9/30/2008

Air-lift	20.3	cm	$Q_{L,ave}$	1109.50	l min^{-1}	dSMOW	998.27
Salinity	33	ppt	$Q_{G,ave}$	1415.59	l min^{-1}	a	0.77
C_s	0.5	mg l^{-1}	Q_G:Q_L	1.28		b	-0.0044
FW_{CO2}	44.01	g mol^{-1}	Alkalinity	111.95	mg $CaCO_3$ l^{-1}	c	0.0005
						p_{sw}	1023.32

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		$C_t - C_{out}$	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
5:22:49 PM	19.7	19.7	7.37	7.46	3.22	2.60	0.63	2.72	1.000
5:23:20 PM	19.7	19.7	7.37	7.46	3.22	2.60	0.63	2.72	1.000
5:23:50 PM	19.7	19.7	7.37	7.46	3.22	2.60	0.63	2.72	1.000
5:24:20 PM	19.7	19.7	7.36	7.46	3.30	2.60	0.70	2.80	1.125
5:24:50 PM	19.7	19.7	7.11	7.36	5.97	3.30	2.67	5.47	4.261
5:25:20 PM	19.7	19.7	6.87	7.13	10.47	5.69	4.77	9.97	7.625
5:25:50 PM	19.7	19.7	6.65	6.98	17.46	8.09	9.36	16.96	14.955
5:26:20 PM	19.7	19.7	6.44	6.78	28.39	12.91	15.49	27.89	24.741
5:26:50 PM	19.7	19.7	6.32	6.65	37.47	17.46	20.01	36.97	31.976
5:27:20 PM	19.7	19.7	6.25	6.55	44.05	22.01	22.04	43.55	35.207
5:27:50 PM	19.7	19.7	6.19	6.50	50.59	24.71	25.88	50.09	41.348
5:28:20 PM	19.7	19.7	6.23	6.56	46.13	21.51	24.62	45.63	39.339
5:28:50 PM	19.7	19.7	6.28	6.63	41.10	18.28	22.81	40.60	36.448
5:29:20 PM	19.7	19.7	6.34	6.74	35.78	14.16	21.61	35.28	34.531
5:29:50 PM	19.7	19.7	6.52	6.84	23.59	11.22	12.37	23.09	19.762
5:30:20 PM	19.7	19.7	6.75	6.94	13.84	8.89	4.95	13.34	7.908
5:30:50 PM	19.7	19.7	6.86	7.03	10.71	7.20	3.51	10.21	5.611
5:31:20 PM	19.7	19.7	6.96	7.10	8.48	6.11	2.37	7.98	3.791
5:31:50 PM	19.7	19.7	7.05	7.16	6.87	5.30	1.57	6.37	2.502
5:32:20 PM	19.7	19.7	7.11	7.22	5.97	4.60	1.36	5.47	2.179
5:32:50 PM	19.7	19.7	7.17	7.25	5.18	4.29	0.89	4.68	1.427

38.1 cm lift_Trial 2_9/30/2008 (continued)

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		C_t - C_{out}	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
5:33:20 PM	19.7	19.7	7.20	7.29	4.83	3.90	0.93	4.33	1.481
5:33:50 PM	19.7	19.7	7.23	7.31	4.50	3.72	0.78	4.00	1.242
5:34:20 PM	19.7	19.7	7.25	7.34	4.29	3.46	0.83	3.79	1.320
5:34:50 PM	19.7	19.7	7.27	7.35	4.09	3.38	0.71	3.59	1.133
5:35:20 PM	19.7	19.7	7.28	7.36	3.99	3.30	0.69	3.49	1.107
5:35:50 PM	19.7	19.7	7.30	7.37	3.81	3.22	0.59	3.31	0.935
5:36:20 PM	19.7	19.7	7.31	7.38	3.72	3.15	0.57	3.22	0.914

45.7 cm lift_Trial 1_10/1/2008

Air-lift	20.3	cm	$Q_{L,ave}$	920.13	l min^{-1}	dSMOW	998.32
Salinity	33	ppt	$Q_{G,ave}$	1415.59	l min^{-1}	a	0.77
C_s	0.5	mg l^{-1}	Q_G:Q_L	1.54		b	-0.0044
FW_{CO2}	44.01	g mol^{-1}	Alkalinity	116.36	mg $CaCO_3$ l^{-1}	c	0.0005
						p_{sw}	1023.39

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		C_t - C_{out}	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
9:30:36 AM	19.5	19.4	7.49	7.64	2.52	1.75	0.77	2.02	1.018
9:31:07 AM	19.5	19.4	7.50	7.64	2.46	1.75	0.71	1.96	0.938
9:31:36 AM	19.5	19.4	7.50	7.65	2.46	1.71	0.75	1.96	0.994
9:32:06 AM	19.5	19.4	7.50	7.65	2.46	1.71	0.75	1.96	0.994
9:32:36 AM	19.5	19.4	7.42	7.64	2.99	1.75	1.23	2.49	1.631
9:33:06 AM	19.5	19.4	7.11	7.51	6.23	2.41	3.82	5.73	5.063
9:33:36 AM	19.5	19.4	6.76	7.27	14.11	4.28	9.83	13.61	13.030
9:34:06 AM	19.5	19.4	6.48	7.00	27.02	8.08	18.93	26.52	25.087
9:34:36 AM	19.4	19.4	6.32	6.81	39.20	12.59	26.60	38.70	35.250
9:35:07 AM	19.4	19.4	6.23	6.71	48.25	15.89	32.37	47.75	42.885
9:35:36 AM	19.4	19.4	6.17	6.62	55.42	19.58	35.85	54.92	47.495
9:36:06 AM	19.4	19.4	6.21	6.61	50.53	20.04	30.50	50.03	40.409
9:36:37 AM	19.4	19.4	6.29	6.65	42.01	18.26	23.75	41.51	31.466
9:37:06 AM	19.4	19.4	6.38	6.71	34.12	15.89	18.23	33.62	24.159
9:37:37 AM	19.4	19.4	6.51	6.79	25.26	13.19	12.07	24.76	15.989
9:38:06 AM	19.4	19.4	6.62	6.87	19.58	10.95	8.63	19.08	11.431

45.7 cm lift_Trial 1_10/1/2008

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		$C_t - C_{out}$	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
9:38:36 AM	19.4	19.4	6.75	6.95	14.48	9.08	5.39	13.98	7.145
9:39:06 AM	19.4	19.4	6.88	7.01	10.70	7.89	2.80	10.20	3.712
9:39:36 AM	19.4	19.4	6.99	7.08	8.27	6.70	1.57	7.77	2.085
9:40:06 AM	19.4	19.4	7.08	7.14	6.70	5.82	0.88	6.20	1.168
9:40:36 AM	19.4	19.4	7.16	7.20	5.55	5.05	0.50	5.05	0.662
9:41:06 AM	19.4	19.4	7.25	7.26	4.49	4.38	0.11	3.99	0.139
9:41:37 AM	19.4	19.4	7.30	7.31	3.98	3.89	0.09	3.48	0.124
9:42:06 AM	19.4	19.4	7.35	7.36	3.54	3.45	0.08	3.04	0.111

45.7 cm lift_Trial 2_10/1/2008

Air-lift	20.3	cm	$Q_{L,ave}$	928.76	l min^{-1}	dSMOW	998.32
Salinity	33	ppt	$Q_{G,ave}$	1415.59	l min^{-1}	a	0.77
C_s	0.5	mg l^{-1}	Q_G:Q_L	1.52		b	-0.0044
FW_{CO2}	44.01	g mol^{-1}	Alkalinity	116.36	mg $CaCO_3$ l^{-1}	c	0.0005
						p_{sw}	1023.38

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		$C_t - C_{out}$	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
10:34:23 AM	19.5	19.4	7.51	7.61	2.40	1.89	0.51	1.90	0.689
10:34:54 AM	19.5	19.4	7.51	7.61	2.40	1.89	0.51	1.90	0.689
10:35:24 AM	19.5	19.4	7.51	7.61	2.40	1.89	0.51	1.90	0.689
10:35:54 AM	19.5	19.4	7.44	7.61	2.84	1.89	0.96	2.34	1.280
10:36:24 AM	19.5	19.4	7.12	7.48	6.08	2.59	3.50	5.58	4.675
10:36:54 AM	19.5	19.4	6.75	7.24	14.44	4.59	9.85	13.94	13.174
10:37:24 AM	19.5	19.4	6.49	6.98	26.40	8.47	17.93	25.90	23.977
10:37:54 AM	19.5	19.4	6.37	6.81	34.84	12.59	22.25	34.34	29.759
10:38:24 AM	19.5	19.4	6.26	6.73	44.92	15.17	29.76	44.42	39.801
10:38:54 AM	19.5	19.4	6.13	6.61	60.65	20.03	40.61	60.15	54.319
10:39:24 AM	19.5	19.4	6.13	6.52	60.65	24.68	35.97	60.15	48.107
10:39:54 AM	19.5	19.5	6.22	6.55	49.27	22.97	26.30	48.77	35.173
10:40:24 AM	19.5	19.4	6.34	6.64	37.34	18.69	18.65	36.84	24.949
10:40:54 AM	19.5	19.4	6.45	6.72	28.96	15.52	13.44	28.46	17.969
10:41:24 AM	19.5	19.4	6.58	6.81	21.43	12.59	8.84	20.93	11.822

45.7 cm lift_Trial 2_10/1/2008 (continued)

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		C_t - C_{out}	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
10:41:54 AM	19.5	19.4	6.69	6.88	16.61	10.70	5.91	16.11	7.902
10:42:24 AM	19.5	19.4	6.81	6.95	12.56	9.08	3.48	12.06	4.653
10:42:54 AM	19.5	19.4	6.92	7.01	9.72	7.89	1.83	9.22	2.444
10:43:24 AM	19.5	19.5	7.01	7.07	7.88	6.84	1.03	7.38	1.382
10:43:54 AM	19.5	19.4	7.11	7.13	6.23	5.96	0.27	5.73	0.365
10:44:24 AM	19.5	19.5	7.17	7.18	5.41	5.28	0.13	4.91	0.169
10:44:54 AM	19.5	19.5	7.22	7.22	4.81	4.81	0.00	4.31	0.000
10:45:24 AM	19.5	19.5	7.28	7.28	4.17	4.17	0.00	3.67	0.000
10:45:54 AM	19.5	19.5	7.32	7.32	3.79	3.79	0.00	3.29	0.000

CTR and $C_{deficit}$ Linear Regression Summary for 20.3 cm air-lift at 1,415 l min^{-1} air

Lift [cm]	Trial	CTR Coefficient for $C_{deficit}$ equations	R^2
38.1	1	CTR = 0.8660*$C_{deficit}$	0.969
38.1	2	CTR = 0.8498*$C_{deficit}$	0.978
45.7	1	CTR = 0.7848*$C_{deficit}$	0.959
45.7	2	CTR = 0.7938*$C_{deficit}$	0.948

SUPPLEMENTAL HYDRAULIC DATA

20.3 cm air-lift

1,700 l air min^{-1}, 43.2 cm lift hydraulic summary data

Lift [cm]	Trial 1 Q_L [l min^{-1}]	Trial 2 Q_L [l min^{-1}]	Trial 3 Q_L [l min^{-1}]
43.2	1141.56	1158.59	1055.64
	1160.86	1068.51	1106.36
	1172.67	1045.80	1156.70
	1094.62	1133.99	1166.54
Ave	1142.43	1101.72	1121.31

1,840 l air min^{-1}, 45.7 cm lift hydraulic summary data

Lift [cm]	Trial 1 Q_L [l min^{-1}]	Trial 2 Q_L [l min^{-1}]	Trial 3 Q_L [l min^{-1}]
45.7	1203.06	1175.39	1257.38
	1212.98	1247.61	1170.70
	1249.92	1156.77	1139.66
	1170.32	1181.71	1196.02
Ave	1209.07	1190.37	1190.94

APPENDIX B:
EXPERIMENTAL AIR-LIFT DATA COLLECTED AT HARBOR BRANCH OCEANOGRAPHIC INSTITUTE (HBOI)

AERATION STUDIES

10.2 cm air-lift_170 l air min^{-1}

10.2 cm air-lift_Trial 1_7/14/2007

Hydraulic Summary

Time	Volume [liters]	Fill time [sec]	Q_L [l min^{-1}]
12:15 PM	20.06	7.28	165.33
12:45 PM	20.06	7.50	160.48
1:15 PM	20.06	7.37	163.31
1:45 PM	20.06	7.47	161.13
2:15 PM	20.06	7.65	157.34
2:45 PM	20.06	7.40	162.65

Lift	**30.5**	**cm**	$Q_{L,ave}$	**161.71**	**l min^{-1}**
Salinity	**1**	**ppt**	$Q_{G,ave}$	**170.00**	**l min^{-1}**
C_s	**8.04**	**mg l^{-1}**	$Q_G:Q_L$	**1.05**	
V_{tank}	**7232**	**liters**			

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		$C_{out} - C_t$	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
12:01:00 PM	26.4	26.6	8.1	8.2	0.1	-0.1	0.023
12:02:00 PM	26.4	26.6	8.1	8.2	0.1	-0.1	0.023
12:03:00 PM	26.4	26.6	8.1	8.1	0.0	-0.1	0.000
12:04:00 PM	26.4	26.6	8.1	8.1	0.0	-0.1	0.000
12:05:00 PM	26.4	26.6	8.1	8.2	0.1	-0.1	0.023
12:06:00 PM	26.4	26.6	8.1	8.2	0.1	-0.1	0.023
12:07:00 PM	26.4	26.6	8.1	8.2	0.1	-0.1	0.023
12:08:00 PM	26.4	26.6	8.2	8.1	-0.1	-0.2	-0.023
12:09:00 PM	26.4	26.6	8.2	8.2	0.0	-0.2	0.000
12:10:00 PM	26.4	26.6	8.2	8.2	0.0	-0.2	0.000
12:11:00 PM	26.4	26.6	8.2	8.2	0.0	-0.2	0.000
12:12:00 PM	26.4	26.6	8.2	8.2	0.0	-0.2	0.000
12:13:00 PM	26.4	26.6	8.2	8.2	0.0	-0.2	0.000
12:14:00 PM	26.4	26.6	8.2	5.0	-3.2	-0.2	-0.745
12:15:00 PM	26.4	26.7	5.9	0.4	-5.5	2.1	-1.281
12:16:00 PM	26.4	26.7	0.2	0.7	0.5	7.8	0.116
12:17:00 PM	26.5	26.7	0.1	3.3	3.2	7.9	0.745

10.2 cm air-lift_Trial 1_7/14/2007 (continued)

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		$C_{out} - C_t$	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
12:18:00 PM	26.5	26.7	0.1	0.4	0.3	7.9	0.070
12:19:00 PM	26.5	26.7	0.1	0.1	0.0	7.9	0.000
12:20:00 PM	26.5	26.7	0.1	0.3	0.2	7.9	0.047
12:21:00 PM	26.5	26.7	0.1	0.2	0.1	7.9	0.023
12:22:00 PM	26.5	26.7	0.1	0.1	0.0	7.9	0.000
12:23:00 PM	26.5	26.7	0.1	0.0	-0.1	7.9	-0.023
12:24:00 PM	26.5	26.7	0.1	0.0	-0.1	7.9	-0.023
12:25:00 PM	26.5	26.7	0.1	0.0	-0.1	7.9	-0.023
12:26:00 PM	26.5	26.7	0.1	0.0	-0.1	7.9	-0.023
12:27:00 PM	26.5	26.7	0.1	0.0	-0.1	7.9	-0.023
12:28:00 PM	26.5	26.7	0.1	0.0	-0.1	7.9	-0.023
12:29:00 PM	26.5	26.7	0.3	0.0	-0.3	7.7	-0.070
12:30:00 PM	26.5	26.7	0.3	0.1	-0.2	7.7	-0.047
12:31:00 PM	26.5	26.7	0.5	0.1	-0.4	7.5	-0.093
12:32:00 PM	26.5	26.7	0.6	0.1	-0.5	7.4	-0.116
12:33:00 PM	26.5	26.7	0.8	0.0	-0.8	7.2	-0.186
12:34:00 PM	26.5	26.7	0.8	0.1	-0.7	7.2	-0.163
12:35:00 PM	26.5	26.7	0.7	0.4	-0.3	7.3	-0.070
12:36:00 PM	26.5	26.7	0.8	0.5	-0.3	7.2	-0.070
12:37:00 PM	26.5	26.7	1.0	0.5	-0.5	7.0	-0.116
12:38:00 PM	26.5	26.7	1.1	0.8	-0.3	6.9	-0.070
12:39:00 PM	26.5	26.7	1.2	1.0	-0.2	6.8	-0.047
12:40:00 PM	26.5	26.7	1.3	1.0	-0.3	6.7	-0.070
12:41:00 PM	26.5	26.7	1.4	1.3	-0.1	6.6	-0.023
12:42:00 PM	26.5	26.7	1.5	1.5	0.0	6.5	0.000
12:43:00 PM	26.5	26.7	1.7	1.5	-0.2	6.3	-0.047
12:44:00 PM	26.5	26.7	1.8	1.8	0.0	6.2	0.000
12:45:00 PM	26.6	26.7	1.9	1.9	0.0	6.1	0.000
12:46:00 PM	26.6	26.7	2.0	2.1	0.1	6.0	0.023
12:47:00 PM	26.6	26.7	2.2	2.1	-0.1	5.8	-0.023
12:48:00 PM	26.6	26.7	2.2	2.3	0.1	5.8	0.023
12:49:00 PM	26.6	26.7	2.3	2.5	0.2	5.7	0.047
12:50:00 PM	26.6	26.7	2.5	2.6	0.1	5.5	0.023
12:51:00 PM	26.6	26.7	2.6	2.7	0.1	5.4	0.023
12:52:00 PM	26.6	26.7	2.7	2.8	0.1	5.3	0.023

10.2 cm air-lift_Trial 1_7/14/2007 (continued)

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		C_{out} - C_t	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
12:53:00 PM	26.6	26.7	2.7	3.0	0.3	5.3	0.070
12:54:00 PM	26.6	26.7	2.8	3.1	0.3	5.2	0.070
12:55:00 PM	26.6	26.7	2.9	3.2	0.3	5.1	0.070
12:56:00 PM	26.6	26.7	2.9	3.2	0.3	5.1	0.070
12:57:00 PM	26.6	26.7	3.0	3.4	0.4	5.0	0.093
12:58:00 PM	26.6	26.7	3.1	3.5	0.4	4.9	0.093
12:59:00 PM	26.6	26.7	3.2	3.6	0.4	4.8	0.093
1:00:00 PM	26.6	26.7	3.2	3.7	0.5	4.8	0.116
1:01:00 PM	26.6	26.7	3.3	3.8	0.5	4.7	0.116
1:02:00 PM	26.6	26.7	3.4	3.9	0.5	4.6	0.116
1:03:00 PM	26.6	26.7	3.5	4.0	0.5	4.5	0.116
1:04:00 PM	26.6	26.7	3.5	4.0	0.5	4.5	0.116
1:05:00 PM	26.6	26.7	3.6	4.1	0.5	4.4	0.116
1:06:00 PM	26.6	26.7	3.7	4.2	0.5	4.3	0.116
1:07:00 PM	26.6	26.7	3.8	4.3	0.5	4.2	0.116
1:08:00 PM	26.6	26.7	3.9	4.3	0.4	4.1	0.093
1:09:00 PM	26.6	26.7	3.9	4.4	0.5	4.1	0.116
1:10:00 PM	26.6	26.7	4.0	4.5	0.5	4.0	0.116
1:11:00 PM	26.6	26.7	4.1	4.6	0.5	3.9	0.116
1:12:00 PM	26.6	26.7	4.1	4.7	0.6	3.9	0.140
1:13:00 PM	26.6	26.7	4.1	4.6	0.5	3.9	0.116
1:14:00 PM	26.6	26.7	4.2	4.5	0.3	3.8	0.070
1:15:00 PM	26.6	26.7	4.2	4.5	0.3	3.8	0.070
1:16:00 PM	26.6	26.7	4.2	4.5	0.3	3.8	0.070
1:17:00 PM	26.6	26.7	4.2	4.7	0.5	3.8	0.116
1:18:00 PM	26.6	26.7	4.2	4.7	0.5	3.8	0.116
1:19:00 PM	26.6	26.8	4.2	4.9	0.7	3.8	0.163
1:20:00 PM	26.6	26.8	4.2	4.9	0.7	3.8	0.163
1:21:00 PM	26.6	26.8	4.3	4.9	0.6	3.7	0.140
1:22:00 PM	26.6	26.8	4.4	5.0	0.6	3.6	0.140
1:23:00 PM	26.6	26.8	4.4	5.1	0.7	3.6	0.163
1:24:00 PM	26.6	26.8	4.5	5.1	0.6	3.5	0.140
1:25:00 PM	26.6	26.8	4.6	5.2	0.6	3.4	0.140
1:26:00 PM	26.6	26.8	4.6	5.3	0.7	3.4	0.163
1:27:00 PM	26.6	26.8	4.6	5.3	0.7	3.4	0.163

10.2 cm air-lift_Trial 1_7/14/2007 (continued)

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		$C_{out} - C_t$	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
1:28:00 PM	26.6	26.8	4.7	5.4	0.7	3.3	0.163
1:29:00 PM	26.6	26.8	4.8	5.5	0.7	3.2	0.163
1:30:00 PM	26.6	26.8	4.8	5.5	0.7	3.2	0.163
1:31:00 PM	26.6	26.8	4.9	5.6	0.7	3.1	0.163
1:32:00 PM	26.6	26.8	4.9	5.6	0.7	3.1	0.163
1:33:00 PM	26.6	26.8	5.0	5.7	0.7	3.0	0.163
1:34:00 PM	26.6	26.8	5.0	5.7	0.7	3.0	0.163
1:35:00 PM	26.6	26.8	5.1	5.8	0.7	2.9	0.163
1:36:00 PM	26.6	26.8	5.1	5.8	0.7	2.9	0.163
1:37:00 PM	26.6	26.8	5.2	5.9	0.7	2.8	0.163
1:38:00 PM	26.6	26.8	5.2	5.9	0.7	2.8	0.163
1:39:00 PM	26.6	26.8	5.3	5.9	0.6	2.7	0.140
1:40:00 PM	26.6	26.8	5.3	6.0	0.7	2.7	0.163
1:41:00 PM	26.6	26.8	5.3	6.0	0.7	2.7	0.163
1:42:00 PM	26.6	26.8	5.3	6.1	0.8	2.7	0.186
1:43:00 PM	26.6	26.8	5.3	6.1	0.8	2.7	0.186
1:44:00 PM	26.6	26.8	5.4	6.2	0.8	2.6	0.186
1:45:00 PM	26.6	26.8	5.5	6.1	0.6	2.5	0.140
1:46:00 PM	26.6	26.8	5.4	6.1	0.7	2.6	0.163
1:47:00 PM	26.6	26.8	5.4	6.2	0.8	2.6	0.186
1:48:00 PM	26.6	26.8	5.4	6.2	0.8	2.6	0.186
1:49:00 PM	26.6	26.8	5.4	6.3	0.9	2.6	0.210
1:50:00 PM	26.6	26.8	5.5	6.3	0.8	2.5	0.186
1:51:00 PM	26.6	26.8	5.5	6.3	0.8	2.5	0.186
1:52:00 PM	26.6	26.8	5.6	6.3	0.7	2.4	0.163
1:53:00 PM	26.6	26.8	5.7	6.4	0.7	2.3	0.163
1:54:00 PM	26.6	26.8	5.7	6.4	0.7	2.3	0.163
1:55:00 PM	26.6	26.8	5.8	6.5	0.7	2.2	0.163
1:56:00 PM	26.6	26.8	5.8	6.5	0.7	2.2	0.163
1:57:00 PM	26.6	26.8	5.8	6.5	0.7	2.2	0.163
1:58:00 PM	26.6	26.8	5.9	6.5	0.6	2.1	0.140
1:59:00 PM	26.6	26.8	5.9	6.6	0.7	2.1	0.163
2:00:00 PM	26.6	26.8	6.0	6.6	0.6	2.0	0.140
2:01:00 PM	26.6	26.8	6.1	6.6	0.5	1.9	0.116
2:02:00 PM	26.6	26.8	6.0	6.7	0.7	2.0	0.163

10.2 cm air-lift_Trial 1_7/14/2007 (continued)

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		C_{out} - C_t	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
2:03:00 PM	26.6	26.8	6.1	6.7	0.6	1.9	0.140
2:04:00 PM	26.6	26.8	6.1	6.7	0.6	1.9	0.140
2:05:00 PM	26.6	26.8	6.2	6.8	0.6	1.8	0.140
2:06:00 PM	26.6	26.8	6.2	6.8	0.6	1.8	0.140
2:07:00 PM	26.6	26.8	6.3	6.8	0.5	1.7	0.116
2:08:00 PM	26.6	26.8	6.2	6.8	0.6	1.8	0.140
2:09:00 PM	26.6	26.8	6.3	6.8	0.5	1.7	0.116
2:10:00 PM	26.6	26.8	6.3	6.9	0.6	1.7	0.140
2:11:00 PM	26.6	26.8	6.4	6.9	0.5	1.6	0.116
2:12:00 PM	26.6	26.8	6.4	6.9	0.5	1.6	0.116
2:13:00 PM	26.6	26.8	6.4	6.9	0.5	1.6	0.116
2:14:00 PM	26.6	26.8	6.5	7.0	0.5	1.5	0.116
2:15:00 PM	26.6	26.8	6.5	7.0	0.5	1.5	0.116
2:16:00 PM	26.6	26.8	6.5	7.0	0.5	1.5	0.116
2:17:00 PM	26.6	26.8	6.6	7.0	0.4	1.4	0.093
2:18:00 PM	26.6	26.8	6.5	7.0	0.5	1.5	0.116
2:19:00 PM	26.6	26.8	6.6	7.0	0.4	1.4	0.093
2:20:00 PM	26.6	26.8	6.6	7.0	0.4	1.4	0.093
2:21:00 PM	26.6	26.8	6.6	7.0	0.4	1.4	0.093
2:22:00 PM	26.6	26.8	6.6	7.1	0.5	1.4	0.116
2:23:00 PM	26.6	26.8	6.6	7.0	0.4	1.4	0.093
2:24:00 PM	26.6	26.8	6.6	7.1	0.5	1.4	0.116
2:25:00 PM	26.6	26.8	6.7	7.1	0.4	1.3	0.093
2:26:00 PM	26.6	26.8	6.7	7.1	0.4	1.3	0.093
2:27:00 PM	26.6	26.8	6.7	7.1	0.4	1.3	0.093
2:28:00 PM	26.6	26.8	6.7	7.2	0.5	1.3	0.116
2:29:00 PM	26.6	26.8	6.8	7.2	0.4	1.2	0.093
2:30:00 PM	26.6	26.8	6.8	7.2	0.4	1.2	0.093
2:31:00 PM	26.6	26.8	6.8	7.2	0.4	1.2	0.093
2:32:00 PM	26.6	26.8	6.8	7.2	0.4	1.2	0.093
2:33:00 PM	26.6	26.8	6.9	7.2	0.3	1.1	0.070
2:34:00 PM	26.6	26.8	6.9	7.2	0.3	1.1	0.070
2:35:00 PM	26.6	26.8	6.9	7.3	0.4	1.1	0.093
2:36:00 PM	26.6	26.8	6.9	7.3	0.4	1.1	0.093
2:37:00 PM	26.6	26.8	6.9	7.3	0.4	1.1	0.093

10.2 cm air-lift_Trial 1_7/14/2007 (continued)

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		$C_{out} - C_t$	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
2:38:00 PM	26.6	26.8	6.9	7.3	0.4	1.1	0.093
2:39:00 PM	26.6	26.8	7.0	7.3	0.3	1.0	0.070
2:40:00 PM	26.6	26.8	7.0	7.3	0.3	1.0	0.070
2:41:00 PM	26.6	26.8	7.0	7.3	0.3	1.0	0.070
2:42:00 PM	26.6	26.8	7.0	7.4	0.4	1.0	0.093
2:43:00 PM	26.6	26.8	7.1	7.4	0.3	0.9	0.070

10.2 cm air-lift_Trial 2_7/23/2007

Hydraulic Summary

Time	Volume [liters]	Fill time [sec]	Q_L [l min^{-1}]
10:30 AM	20.06	7.41	162.43
10:45 AM	20.06	7.53	159.84
11:15 AM	20.06	7.50	160.48
1:15 PM	20.06	7.34	163.98

Lift	30.5	cm	$Q_{L,ave}$	161.68	l min^{-1}
Salinity	1	ppt	$Q_{G,ave}$	170.00	l min^{-1}
C_s	8.18	mg l^{-1}	Q_G:Q_L	1.05	
V_{tank}	7232	liters			

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		$C_{out} - C_t$	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
10:45:48 AM	26.8	25.2	8.3	8.4	0.1	-0.1	0.023
10:46:48 AM	26.8	25.2	8.3	8.4	0.1	-0.1	0.023
10:47:48 AM	26.7	25.2	8.3	8.4	0.1	-0.1	0.023
10:48:48 AM	26.7	25.2	0.2	1.3	1.1	8.0	0.256
10:49:48 AM	26.7	25.2	0.1	5.3	5.2	8.1	1.211
10:50:48 AM	26.7	25.3	0.1	0.2	0.1	8.1	0.023
10:51:48 AM	26.7	25.3	0.1	1.8	1.7	8.1	0.396
10:52:48 AM	26.7	25.3	0.1	0.1	0.0	8.1	0.000
10:53:48 AM	26.7	25.3	0.1	0.0	-0.1	8.1	-0.023
10:54:48 AM	26.7	25.3	0.1	0.0	-0.1	8.1	-0.023

10.2 cm air-lift_Trial 2_7/23/2007 (continued)

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		$C_{out} - C_t$	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
10:55:48 AM	26.7	25.3	0.1	0.0	-0.1	8.1	-0.023
10:56:48 AM	26.6	25.3	0.1	0.0	-0.1	8.1	-0.023
10:57:48 AM	26.6	25.3	0.1	0.0	-0.1	8.1	-0.023
10:58:48 AM	26.6	25.3	0.1	0.0	-0.1	8.1	-0.023
10:59:48 AM	26.6	25.3	0.1	0.0	-0.1	8.1	-0.023
11:00:48 AM	26.6	25.3	0.1	0.0	-0.1	8.1	-0.023
11:01:48 AM	26.5	25.3	0.0	0.0	0.0	8.2	0.000
11:02:48 AM	26.6	25.3	0.0	0.1	0.1	8.2	0.023
11:03:48 AM	26.6	25.3	0.0	0.2	0.2	8.2	0.047
11:04:48 AM	26.6	25.3	0.0	0.4	0.4	8.2	0.093
11:05:48 AM	26.6	25.3	0.1	0.4	0.3	8.1	0.070
11:06:48 AM	26.6	25.3	0.1	0.7	0.6	8.1	0.140
11:07:48 AM	26.6	25.3	0.1	0.8	0.7	8.1	0.163
11:08:50 AM	26.5	25.3	0.2	1.0	0.8	8.0	0.186
11:09:50 AM	26.5	25.3	0.3	1.1	0.8	7.9	0.186
11:10:50 AM	26.5	25.3	0.4	1.3	0.9	7.8	0.210
11:11:50 AM	26.5	25.3	0.5	1.4	0.9	7.7	0.210
11:12:50 AM	26.5	25.3	0.7	1.4	0.7	7.5	0.163
11:13:50 AM	26.5	25.3	0.6	1.7	1.1	7.6	0.256
11:14:50 AM	26.5	25.3	0.7	1.6	0.9	7.5	0.210
11:15:50 AM	26.5	25.3	0.9	1.8	0.9	7.3	0.210
11:16:50 AM	26.4	25.3	1.0	2.1	1.1	7.2	0.256
11:17:50 AM	26.5	25.3	1.1	2.2	1.1	7.1	0.256
11:18:50 AM	26.4	25.3	1.2	2.3	1.1	7.0	0.256
11:19:49 AM	26.4	25.3	1.3	2.4	1.1	6.9	0.256
11:20:49 AM	26.4	25.3	1.4	2.5	1.1	6.8	0.256
11:21:49 AM	26.3	25.3	1.5	2.7	1.2	6.7	0.279
11:22:49 AM	26.4	25.3	1.6	2.8	1.2	6.6	0.279
11:23:49 AM	26.3	25.3	1.6	2.9	1.3	6.6	0.303
11:24:49 AM	26.3	25.3	1.7	3.0	1.3	6.5	0.303
11:25:49 AM	26.3	25.3	1.9	3.1	1.2	6.3	0.279
11:26:49 AM	26.3	25.3	2.0	3.2	1.2	6.2	0.279
11:27:49 AM	26.3	25.3	2.1	3.4	1.3	6.1	0.303
11:28:49 AM	26.4	25.3	2.1	3.5	1.4	6.1	0.326
11:29:49 AM	26.3	25.3	2.3	3.5	1.2	5.9	0.279

10.2 cm air-lift_Trial 2_7/23/2007 (continued)

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		$C_{out} - C_t$	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
11:30:49 AM	26.3	25.3	2.3	3.7	1.4	5.9	0.326
11:31:49 AM	26.3	25.3	2.5	3.7	1.2	5.7	0.279
11:32:49 AM	26.3	25.3	2.5	3.9	1.4	5.7	0.326
11:33:49 AM	26.3	25.3	2.7	4.0	1.3	5.5	0.303
11:34:49 AM	26.3	25.3	2.7	4.0	1.3	5.5	0.303
11:35:50 AM	26.3	25.3	2.8	4.1	1.3	5.4	0.303
11:36:49 AM	26.3	25.3	2.9	4.2	1.3	5.3	0.303
11:37:49 AM	26.3	25.3	3.0	4.3	1.3	5.2	0.303
11:38:51 AM	26.3	25.3	3.1	4.3	1.2	5.1	0.279
11:39:51 AM	26.3	25.3	3.2	4.4	1.2	5.0	0.279
11:40:51 AM	26.3	25.3	3.3	4.5	1.2	4.9	0.279
11:41:51 AM	26.3	25.3	3.4	4.6	1.2	4.8	0.279
11:42:51 AM	26.3	25.3	3.5	4.7	1.2	4.7	0.279
11:43:51 AM	26.3	25.3	3.5	4.7	1.2	4.7	0.279
11:44:51 AM	26.3	25.3	3.7	4.8	1.1	4.5	0.256
11:45:51 AM	26.3	25.3	3.7	4.9	1.2	4.5	0.279
11:46:51 AM	26.3	25.3	3.7	4.9	1.2	4.5	0.279
11:47:51 AM	26.2	25.3	3.7	5.0	1.3	4.5	0.303
11:48:51 AM	26.3	25.3	3.9	5.1	1.2	4.3	0.279
11:49:51 AM	26.3	25.3	3.9	5.1	1.2	4.3	0.279
11:50:51 AM	26.3	25.3	4.1	5.2	1.1	4.1	0.256
11:51:51 AM	26.2	25.3	4.1	5.2	1.1	4.1	0.256
11:52:51 AM	26.3	25.3	4.2	5.3	1.1	4.0	0.256
11:53:51 AM	26.3	25.3	4.2	5.3	1.1	4.0	0.256
11:54:51 AM	26.3	25.3	4.2	5.4	1.2	4.0	0.279
11:55:51 AM	26.2	25.3	4.4	5.4	1.0	3.8	0.233
11:56:51 AM	26.2	25.3	4.4	5.5	1.1	3.8	0.256
11:57:51 AM	26.2	25.3	4.5	5.5	1.0	3.7	0.233
11:58:51 AM	26.3	25.3	4.5	5.6	1.1	3.7	0.256
11:59:51 AM	26.3	25.3	4.7	5.6	0.9	3.5	0.210
12:00:51 PM	26.2	25.3	4.6	5.7	1.1	3.6	0.256
12:01:51 PM	26.3	25.3	4.7	5.7	1.0	3.5	0.233
12:02:51 PM	26.2	25.3	4.8	5.8	1.0	3.4	0.233
12:03:51 PM	26.2	25.3	4.8	5.8	1.0	3.4	0.233
12:04:51 PM	26.2	25.3	5.0	5.8	0.8	3.2	0.186

10.2 cm air-lift_Trial 2_7/23/2007 (continued)

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		$C_{out} - C_t$	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
12:05:51 PM	26.2	25.3	4.9	5.9	1.0	3.3	0.233
12:06:52 PM	26.2	25.3	5.0	5.9	0.9	3.2	0.210
12:07:52 PM	26.2	25.3	5.1	6.0	0.9	3.1	0.210
12:08:52 PM	26.2	25.3	5.1	6.0	0.9	3.1	0.210
12:09:52 PM	26.2	25.3	5.2	6.1	0.9	3.0	0.210
12:10:52 PM	26.2	25.3	5.3	6.1	0.8	2.9	0.186
12:11:52 PM	26.2	25.3	5.3	6.1	0.8	2.9	0.186
12:12:52 PM	26.2	25.3	5.4	6.2	0.8	2.8	0.186
12:13:52 PM	26.2	25.3	5.4	6.2	0.8	2.8	0.186
12:14:52 PM	26.1	25.3	5.4	6.3	0.9	2.8	0.210
12:15:52 PM	26.2	25.3	5.4	6.3	0.9	2.8	0.210
12:16:52 PM	26.2	25.3	5.5	6.3	0.8	2.7	0.186
12:17:52 PM	26.2	25.3	5.6	6.4	0.8	2.6	0.186
12:18:52 PM	26.2	25.3	5.6	6.4	0.8	2.6	0.186
12:19:52 PM	26.2	25.3	5.7	6.4	0.7	2.5	0.163
12:20:52 PM	26.2	25.3	5.6	6.5	0.9	2.6	0.210
12:21:52 PM	26.2	25.3	5.7	6.5	0.8	2.5	0.186
12:22:52 PM	26.2	25.3	5.7	6.5	0.8	2.5	0.186
12:23:52 PM	26.2	25.4	5.7	6.5	0.8	2.5	0.186
12:24:52 PM	26.2	25.4	5.8	6.6	0.8	2.4	0.186
12:25:52 PM	26.2	25.4	5.8	6.6	0.8	2.4	0.186
12:26:52 PM	26.1	25.4	5.9	6.6	0.7	2.3	0.163
12:27:52 PM	26.2	25.4	5.9	6.7	0.8	2.3	0.186
12:28:52 PM	26.1	25.4	5.9	6.7	0.8	2.3	0.186
12:29:52 PM	26.1	25.4	6.0	6.7	0.7	2.2	0.163
12:30:52 PM	26.2	25.4	6.1	6.8	0.7	2.1	0.163
12:31:52 PM	26.1	25.4	6.1	6.8	0.7	2.1	0.163
12:32:52 PM	26.2	25.4	6.2	6.8	0.6	2.0	0.140
12:33:54 PM	26.2	25.4	6.2	6.8	0.6	2.0	0.140
12:34:53 PM	26.2	25.4	6.2	6.8	0.6	2.0	0.140
12:35:53 PM	26.2	25.4	6.2	6.9	0.7	2.0	0.163
12:36:53 PM	26.2	25.4	6.3	6.9	0.6	1.9	0.140
12:37:53 PM	26.2	25.4	6.3	6.9	0.6	1.9	0.140
12:38:53 PM	26.2	25.4	6.3	6.9	0.6	1.9	0.140
12:39:53 PM	26.2	25.4	6.4	6.9	0.5	1.8	0.116

10.2 cm air-lift_Trial 2_7/23/2007 (continued)

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		C_{out} - C_t	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
12:40:53 PM	26.2	25.4	6.4	7.0	0.6	1.8	0.140
12:41:53 PM	26.2	25.4	6.4	7.0	0.6	1.8	0.140
12:42:53 PM	26.2	25.4	6.5	7.0	0.5	1.7	0.116
12:43:53 PM	26.2	25.4	6.5	7.0	0.5	1.7	0.116
12:44:53 PM	26.2	25.4	6.5	7.0	0.5	1.7	0.116
12:45:53 PM	26.2	25.4	6.5	7.1	0.6	1.7	0.140
12:46:53 PM	26.2	25.4	6.6	7.1	0.5	1.6	0.116
12:47:53 PM	26.2	25.4	6.5	7.1	0.6	1.7	0.140
12:48:53 PM	26.2	25.4	6.6	7.1	0.5	1.6	0.116
12:49:53 PM	26.2	25.4	6.6	7.2	0.6	1.6	0.140
12:50:53 PM	26.2	25.4	6.6	7.2	0.6	1.6	0.140
12:51:53 PM	26.2	25.4	6.6	7.2	0.6	1.6	0.140
12:52:53 PM	26.2	25.4	6.6	7.2	0.6	1.6	0.140
12:53:53 PM	26.2	25.4	6.7	7.2	0.5	1.5	0.116
12:54:53 PM	26.2	25.4	6.8	7.2	0.4	1.4	0.093
12:55:53 PM	26.2	25.4	6.8	7.3	0.5	1.4	0.116
12:56:53 PM	26.2	25.4	6.8	7.3	0.5	1.4	0.116
12:57:53 PM	26.2	25.4	6.8	7.3	0.5	1.4	0.116
12:58:53 PM	26.2	25.4	6.8	7.3	0.5	1.4	0.116
12:59:55 PM	26.2	25.4	6.9	7.3	0.4	1.3	0.093
1:00:55 PM	26.2	25.4	6.9	7.3	0.4	1.3	0.093
1:01:55 PM	26.2	25.4	6.9	7.4	0.5	1.3	0.116
1:02:55 PM	26.2	25.4	7.0	7.4	0.4	1.2	0.093
1:03:55 PM	26.2	25.4	7.0	7.4	0.4	1.2	0.093
1:04:55 PM	26.2	25.4	7.0	7.4	0.4	1.2	0.093
1:05:55 PM	26.2	25.4	7.0	7.4	0.4	1.2	0.093
1:06:55 PM	26.2	25.4	7.1	7.4	0.3	1.1	0.070
1:07:55 PM	26.2	25.4	7.1	7.4	0.3	1.1	0.070
1:08:55 PM	26.2	25.4	7.1	7.5	0.4	1.1	0.093
1:09:55 PM	26.2	25.4	7.0	7.5	0.5	1.2	0.116
1:10:55 PM	26.2	25.4	7.0	7.4	0.4	1.2	0.093
1:11:55 PM	26.2	25.4	7.1	7.5	0.4	1.1	0.093
1:12:55 PM	26.2	25.4	7.0	7.5	0.5	1.2	0.116
1:13:55 PM	26.2	25.4	7.0	7.5	0.5	1.2	0.116
1:14:55 PM	26.2	25.4	7.0	7.5	0.5	1.2	0.116

10.2 cm air-lift_Trial 2_7/23/2007 (continued)

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		$C_{out} - C_t$	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
1:15:55 PM	26.2	25.4	7.1	7.5	0.4	1.1	0.093
1:16:55 PM	26.2	25.4	7.0	7.5	0.5	1.2	0.116
1:17:55 PM	26.2	25.4	7.1	7.5	0.4	1.1	0.093
1:18:55 PM	26.2	25.4	7.1	7.5	0.4	1.1	0.093
1:19:55 PM	26.2	25.4	7.2	7.5	0.3	1.0	0.070
1:20:55 PM	26.2	25.4	7.2	7.5	0.3	1.0	0.070
1:21:55 PM	26.2	25.4	7.2	7.5	0.3	1.0	0.070
1:22:55 PM	26.2	25.4	7.2	7.5	0.3	1.0	0.070
1:23:55 PM	26.2	25.4	7.2	7.6	0.4	1.0	0.093

10.2 cm air-lift_Trial 3_7/23/2007

Hydraulic Summary

Time	Volume [liters]	Fill time [sec]	Q_L [l min^{-1}]
4:00 PM	20.06	7.34	163.98
4:45 PM	20.06	7.30	164.88
5:30 PM	20.06	7.23	166.47
6:00 PM	20.06	7.46	161.34

Lift	**30.5**	**cm**	$Q_{L,ave}$	**164.17**	**l min^{-1}**
Salinity	**1**	**ppt**	$Q_{G,ave}$	**170.00**	**l min^{-1}**
C_s	**8.16**	**mg l^{-1}**	Q_G:Q_L	**1.04**	
V_{tank}	**7232**	**liters**			

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		$C_{out} - C_t$	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
3:57:00 PM	26.8	25.7	8.2	8.2	0.0	0.0	0.000
3:58:00 PM	27.1	25.6	8.2	8.3	0.1	0.0	0.024
3:59:00 PM	27.0	25.5	8.2	8.3	0.1	0.0	0.024
4:00:00 PM	27.0	25.5	8.2	8.3	0.1	0.0	0.024
4:01:00 PM	26.9	25.5	8.2	8.3	0.1	0.0	0.024
4:02:00 PM	26.9	25.5	8.2	8.3	0.1	0.0	0.024
4:03:00 PM	26.9	25.5	8.2	8.3	0.1	0.0	0.024

10.2 cm air-lift_Trial 3_7/23/2007 (continued)

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		$C_{out} - C_t$	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
4:04:00 PM	26.8	25.5	8.2	8.3	0.1	0.0	0.024
4:05:00 PM	26.8	25.5	8.2	8.3	0.1	0.0	0.024
4:06:00 PM	26.8	25.5	8.2	8.3	0.1	0.0	0.024
4:07:00 PM	26.7	25.5	8.2	8.3	0.1	0.0	0.024
4:08:00 PM	26.8	25.5	8.2	8.3	0.1	0.0	0.024
4:09:00 PM	26.7	25.5	8.2	8.3	0.1	0.0	0.024
4:10:00 PM	26.7	25.5	8.3	8.3	0.0	-0.1	0.000
4:11:00 PM	26.7	25.5	8.3	8.3	0.0	-0.1	0.000
4:12:00 PM	26.6	25.5	8.3	8.3	0.0	-0.1	0.000
4:13:00 PM	26.6	25.5	8.3	8.3	0.0	-0.1	0.000
4:14:00 PM	26.6	25.5	3.7	4.8	1.1	4.5	0.260
4:15:00 PM	26.6	25.5	0.2	0.6	0.4	8.0	0.095
4:16:00 PM	26.6	25.5	0.1	4.2	4.1	8.1	0.969
4:17:00 PM	26.5	25.5	0.1	1.3	1.2	8.1	0.284
4:18:00 PM	26.5	25.5	0.1	0.1	0.0	8.1	0.000
4:19:00 PM	26.6	25.5	0.1	0.3	0.2	8.1	0.047
4:20:01 PM	26.6	25.5	0.1	0.3	0.2	8.1	0.047
4:21:01 PM	26.5	25.5	0.1	0.0	-0.1	8.1	-0.024
4:22:01 PM	26.5	25.5	0.1	0.0	-0.1	8.1	-0.024
4:23:01 PM	26.5	25.5	0.1	0.0	-0.1	8.1	-0.024
4:24:01 PM	26.5	25.6	0.1	0.0	-0.1	8.1	-0.024
4:25:01 PM	26.5	25.6	0.2	0.0	-0.2	8.0	-0.047
4:26:01 PM	26.5	25.6	0.1	0.1	0.0	8.1	0.000
4:27:01 PM	26.5	25.5	0.2	0.0	-0.2	8.0	-0.047
4:28:01 PM	26.4	25.5	0.3	0.1	-0.2	7.9	-0.047
4:29:01 PM	26.4	25.6	0.4	0.1	-0.3	7.8	-0.071
4:30:01 PM	26.4	25.5	0.6	0.3	-0.3	7.6	-0.071
4:31:01 PM	26.4	25.5	0.6	0.4	-0.2	7.6	-0.047
4:32:01 PM	26.5	25.6	0.7	0.6	-0.1	7.5	-0.024
4:33:01 PM	26.5	25.5	0.8	0.7	-0.1	7.4	-0.024
4:34:01 PM	26.4	25.6	0.9	0.8	-0.1	7.3	-0.024
4:35:01 PM	26.4	25.6	1.0	1.0	0.0	7.2	0.000
4:36:01 PM	26.4	25.6	1.1	1.0	-0.1	7.1	-0.024
4:37:01 PM	26.4	25.6	1.2	1.2	0.0	7.0	0.000
4:38:01 PM	26.4	25.6	1.2	1.5	0.3	7.0	0.071

10.2 cm air-lift_Trial 3_7/23/2007 (continued)

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		$C_{out} - C_t$	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
4:39:01 PM	26.4	25.6	1.4	1.5	0.1	6.8	0.024
4:40:01 PM	26.4	25.6	1.5	1.7	0.2	6.7	0.047
4:41:01 PM	26.3	25.6	1.6	1.8	0.2	6.6	0.047
4:42:01 PM	26.4	25.6	1.7	2.0	0.3	6.5	0.071
4:43:01 PM	26.3	25.6	1.9	2.1	0.2	6.3	0.047
4:44:01 PM	26.4	25.6	1.9	2.3	0.4	6.3	0.095
4:45:01 PM	26.3	25.6	2.1	2.4	0.3	6.1	0.071
4:46:01 PM	26.4	25.6	2.1	2.5	0.4	6.1	0.095
4:47:01 PM	26.3	25.6	2.2	2.6	0.4	6.0	0.095
4:48:01 PM	26.3	25.6	2.3	2.7	0.4	5.9	0.095
4:49:01 PM	26.3	25.6	2.4	2.8	0.4	5.8	0.095
4:50:01 PM	26.4	25.6	2.5	2.9	0.4	5.7	0.095
4:51:03 PM	26.3	25.6	2.6	3.1	0.5	5.6	0.118
4:52:03 PM	26.3	25.6	2.7	3.2	0.5	5.5	0.118
4:53:02 PM	26.3	25.6	2.7	2.9	0.2	5.5	0.047
4:54:02 PM	26.3	25.6	2.7	3.2	0.5	5.5	0.118
4:55:02 PM	26.4	25.6	2.8	3.3	0.5	5.4	0.118
4:56:02 PM	26.3	25.6	2.8	3.4	0.6	5.4	0.142
4:57:02 PM	26.4	25.6	3.0	3.5	0.5	5.2	0.118
4:58:02 PM	26.3	25.6	3.0	3.6	0.6	5.2	0.142
4:59:02 PM	26.3	25.6	3.1	3.7	0.6	5.1	0.142
5:00:02 PM	26.3	25.6	3.1	3.8	0.7	5.1	0.165
5:01:02 PM	26.3	25.6	3.2	3.8	0.6	5.0	0.142
5:02:02 PM	26.3	25.6	3.2	3.9	0.7	5.0	0.165
5:03:02 PM	26.3	25.6	3.4	4.1	0.7	4.8	0.165
5:04:02 PM	26.3	25.6	3.3	4.1	0.8	4.9	0.189
5:05:02 PM	26.3	25.6	3.5	4.2	0.7	4.7	0.165
5:06:02 PM	26.3	25.6	3.5	4.3	0.8	4.7	0.189
5:07:02 PM	26.4	25.6	3.7	4.4	0.7	4.5	0.165
5:08:02 PM	26.4	25.6	3.7	4.4	0.7	4.5	0.165
5:09:03 PM	26.4	25.6	3.7	4.5	0.8	4.5	0.189
5:10:02 PM	26.4	25.6	3.9	4.6	0.7	4.3	0.165
5:11:02 PM	26.4	25.6	4.0	4.7	0.7	4.2	0.165
5:12:02 PM	26.3	25.6	4.0	4.8	0.8	4.2	0.189
5:13:02 PM	26.3	25.6	4.0	4.8	0.8	4.2	0.189

10.2 cm air-lift_Trial 3_7/23/2007 (continued)

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		$C_{out} - C_t$	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
5:14:02 PM	26.3	25.6	4.1	4.9	0.8	4.1	0.189
5:15:02 PM	26.3	25.6	4.2	5.0	0.8	4.0	0.189
5:16:02 PM	26.3	25.6	4.3	5.0	0.7	3.9	0.165
5:17:02 PM	26.2	25.6	4.3	5.1	0.8	3.9	0.189
5:18:03 PM	26.3	25.6	4.4	5.1	0.7	3.8	0.165
5:19:02 PM	26.3	25.6	4.4	5.2	0.8	3.8	0.189
5:20:04 PM	26.3	25.6	4.5	5.2	0.7	3.7	0.165
5:21:04 PM	26.3	25.6	4.6	5.3	0.7	3.6	0.165
5:22:04 PM	26.3	25.6	4.7	5.4	0.7	3.5	0.165
5:23:04 PM	26.3	25.6	4.7	5.4	0.7	3.5	0.165
5:24:04 PM	26.3	25.6	4.8	5.4	0.6	3.4	0.142
5:25:04 PM	26.3	25.6	4.8	5.5	0.7	3.4	0.165
5:26:04 PM	26.3	25.6	4.9	5.6	0.7	3.3	0.165
5:27:04 PM	26.3	25.6	4.9	5.6	0.7	3.3	0.165
5:28:04 PM	26.3	25.6	5.0	5.7	0.7	3.2	0.165
5:29:04 PM	26.3	25.6	5.1	5.7	0.6	3.1	0.142
5:30:04 PM	26.3	25.6	5.1	5.8	0.7	3.1	0.165
5:31:04 PM	26.3	25.6	5.2	5.8	0.6	3.0	0.142
5:32:04 PM	26.3	25.6	5.2	5.9	0.7	3.0	0.165
5:33:04 PM	26.3	25.6	5.3	5.9	0.6	2.9	0.142
5:34:04 PM	26.3	25.6	5.2	5.8	0.6	3.0	0.142
5:35:04 PM	26.3	25.6	5.1	5.8	0.7	3.1	0.165
5:36:04 PM	26.3	25.6	5.2	5.9	0.7	3.0	0.165
5:37:04 PM	26.3	25.6	5.2	5.9	0.7	3.0	0.165
5:38:04 PM	26.3	25.6	5.3	5.9	0.6	2.9	0.142
5:39:04 PM	26.3	25.6	5.3	6.0	0.7	2.9	0.165
5:40:04 PM	26.3	25.6	5.4	6.0	0.6	2.8	0.142
5:41:04 PM	26.3	25.6	5.5	6.1	0.6	2.7	0.142
5:42:04 PM	26.3	25.6	5.5	6.1	0.6	2.7	0.142
5:43:04 PM	26.3	25.6	5.5	6.1	0.6	2.7	0.142
5:44:04 PM	26.3	25.6	5.7	6.2	0.5	2.5	0.118
5:45:04 PM	26.3	25.6	5.6	6.2	0.6	2.6	0.142
5:46:04 PM	26.3	25.6	5.7	6.3	0.6	2.5	0.142
5:47:05 PM	26.3	25.6	5.7	6.3	0.6	2.5	0.142
5:48:05 PM	26.3	25.6	5.9	6.3	0.4	2.3	0.095

10.2 cm air-lift_Trial 3_7/23/2007 (continued)

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		$C_{out} - C_t$	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
5:49:05 PM	26.3	25.6	5.8	6.4	0.6	2.4	0.142
5:50:05 PM	26.3	25.6	5.8	6.4	0.6	2.4	0.142
5:51:05 PM	26.3	25.6	6.0	6.5	0.5	2.2	0.118
5:52:05 PM	26.3	25.6	6.0	6.4	0.4	2.2	0.095
5:53:05 PM	26.3	25.6	6.0	6.5	0.5	2.2	0.118
5:54:05 PM	26.3	25.6	6.0	6.5	0.5	2.2	0.118
5:55:05 PM	26.3	25.6	6.1	6.5	0.4	2.1	0.095
5:56:05 PM	26.3	25.6	6.1	6.6	0.5	2.1	0.118
5:57:05 PM	26.3	25.6	6.2	6.6	0.4	2.0	0.095
5:58:05 PM	26.3	25.6	6.2	6.6	0.4	2.0	0.095
5:59:05 PM	26.3	25.6	6.3	6.7	0.4	1.9	0.095
6:00:05 PM	26.3	25.6	6.2	6.7	0.5	2.0	0.118
6:01:05 PM	26.3	25.6	6.3	6.7	0.4	1.9	0.095
6:02:05 PM	26.3	25.6	6.3	6.8	0.5	1.9	0.118
6:03:05 PM	26.3	25.6	6.4	6.8	0.4	1.8	0.095
6:04:05 PM	26.3	25.6	6.4	6.8	0.4	1.8	0.095
6:05:05 PM	26.3	25.6	6.5	6.9	0.4	1.7	0.095
6:06:05 PM	26.3	25.6	6.6	6.9	0.3	1.6	0.071
6:07:05 PM	26.3	25.6	6.5	6.9	0.4	1.7	0.095
6:08:05 PM	26.3	25.6	6.6	6.9	0.3	1.6	0.071
6:09:05 PM	26.3	25.6	6.6	7.0	0.4	1.6	0.095
6:10:05 PM	26.3	25.6	6.6	7.0	0.4	1.6	0.095
6:11:05 PM	26.3	25.6	6.7	7.0	0.3	1.5	0.071
6:12:05 PM	26.3	25.6	6.7	7.0	0.3	1.5	0.071
6:13:06 PM	26.3	25.6	6.7	7.0	0.3	1.5	0.071
6:14:06 PM	26.3	25.6	6.8	7.1	0.3	1.4	0.071
6:15:06 PM	26.4	25.6	6.8	7.1	0.3	1.4	0.071
6:16:06 PM	26.3	25.6	6.8	7.1	0.3	1.4	0.071
6:17:06 PM	26.3	25.6	6.8	7.1	0.3	1.4	0.071
6:18:06 PM	26.3	25.6	6.8	7.2	0.4	1.4	0.095
6:19:06 PM	26.4	25.6	6.9	7.2	0.3	1.3	0.071
6:20:06 PM	26.3	25.6	6.9	7.2	0.3	1.3	0.071
6:21:06 PM	26.3	25.6	6.9	7.2	0.3	1.3	0.071
6:22:06 PM	26.4	25.6	7.0	7.2	0.2	1.2	0.047
6:23:06 PM	26.4	25.6	7.0	7.3	0.3	1.2	0.071

10.2 cm air-lift_Trial 3_7/23/2007 (continued)

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		$C_{out} - C_t$	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
6:24:06 PM	26.4	25.6	7.0	7.3	0.3	1.2	0.071
6:25:06 PM	26.3	25.6	7.0	7.3	0.3	1.2	0.071
6:26:06 PM	26.3	25.6	7.1	7.3	0.2	1.1	0.047
6:27:06 PM	26.3	25.6	7.1	7.3	0.2	1.1	0.047
6:28:06 PM	26.3	25.6	7.1	7.3	0.2	1.1	0.047
6:29:06 PM	26.4	25.6	7.1	7.4	0.3	1.1	0.071
6:30:06 PM	26.3	25.6	7.2	7.4	0.2	1.0	0.047
6:31:06 PM	26.3	25.6	7.1	7.4	0.3	1.1	0.071
6:32:07 PM	26.4	25.6	7.2	7.4	0.2	1.0	0.047
6:33:06 PM	26.3	25.6	7.2	7.4	0.2	1.0	0.047
6:34:07 PM	26.3	25.6	7.2	7.4	0.2	1.0	0.047
6:35:06 PM	26.3	25.6	7.2	7.4	0.2	1.0	0.047
6:36:06 PM	26.4	25.6	7.2	7.5	0.3	1.0	0.071
6:37:06 PM	26.4	25.6	7.2	7.5	0.3	1.0	0.071
6:38:07 PM	26.4	25.6	7.3	7.5	0.2	0.9	0.047
6:39:07 PM	26.3	25.6	7.3	7.5	0.2	0.9	0.047
6:40:07 PM	26.3	25.6	7.3	7.5	0.2	0.9	0.047
6:41:07 PM	26.4	25.6	7.3	7.5	0.2	0.9	0.047
6:42:08 PM	26.3	25.6	7.4	7.6	0.2	0.8	0.047
6:43:07 PM	26.3	25.6	7.4	7.6	0.2	0.8	0.047
6:44:08 PM	26.3	25.6	7.4	7.6	0.2	0.8	0.047
6:45:07 PM	26.4	25.6	7.4	7.6	0.2	0.8	0.047
6:46:08 PM	26.3	25.6	7.4	7.6	0.2	0.8	0.047
6:47:08 PM	26.3	25.6	7.5	7.6	0.1	0.7	0.024
6:48:07 PM	26.4	25.6	7.5	7.6	0.1	0.7	0.024
6:49:08 PM	26.3	25.6	7.5	7.7	0.2	0.7	0.047
6:50:07 PM	26.3	25.6	7.5	7.7	0.2	0.7	0.047
6:51:08 PM	26.3	25.6	7.5	7.7	0.2	0.7	0.047
6:52:07 PM	26.3	25.6	7.5	7.7	0.2	0.7	0.047
6:53:08 PM	26.3	25.6	7.5	7.7	0.2	0.7	0.047
6:54:07 PM	26.3	25.6	7.6	7.7	0.1	0.6	0.024
6:55:08 PM	26.3	25.6	7.6	7.7	0.1	0.6	0.024
6:56:08 PM	26.3	25.6	7.6	7.7	0.1	0.6	0.024
6:57:08 PM	26.3	25.6	7.6	7.7	0.1	0.6	0.024
6:58:08 PM	26.3	25.6	7.6	7.8	0.2	0.6	0.047

OTR and $C_{deficit}$ Linear Regression Summary at 170 l min^{-1} air injection

Air-lift [cm]	Trial	Lift [cm]	OTR Coefficient for $C_{deficit}$ equations	R^2
10.2	1	30.5	OTR =0.0655*$C_{deficit}$	0.915
10.2	2	30.5	OTR = 0.0617*$C_{deficit}$	0.920
10.2	3	30.5	OTR = 0.0479*$C_{deficit}$	0.958

K_La and SOTR Summary for 170 l min^{-1} air injection

		K_La [min^{-1}]		K_La_{20} [min^{-1}]		SOTR [kg hr^{-1}]	
Air-lift [cm]	**Trial**	**Inlet**	**Outlet**	**Inlet**	**Outlet**	**Inlet**	**Outlet**
10.2	1	0.015	0.019	0.013	0.016	0.0504	0.0625
10.2	2	0.016	0.019	0.014	0.016	0.0559	0.0648
10.2	3	0.017	0.019	0.015	0.016	0.0588	0.0639
	Ave	**0.016**	**0.019**	**0.014**	**0.016**	**0.0550**	**0.0637**
	St. D.	**0.001**	**0.000**	**0.001**	**0.000**	**0.0043**	**0.0012**

AERATION STUDIES (continued)

15.2 cm air-lift_340 l air min^{-1}

15.2 cm air-lift_Trial 1_7/16/2007

Hydraulic Summary

Time	Volume [liters]	Fill time [sec]	Q_L [l min^{-1}]
2:15 PM	20.06	3.68	327.07
2:45 PM	20.06	3.44	349.88
3:15 PM	20.06	3.43	350.90

Lift	30.5	cm	$Q_{L,ave}$	342.62	l min^{-1}
Salinity	1	ppt	$Q_{G,ave}$	340.00	l min^{-1}
C_s	8.08	mg l^{-1}	Q_G:Q_L	0.99	
V_{tank}	7973	liters			

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		C_{out} - C_t	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
2:14:40 PM	26.2	26.4	8.2	8.2	0.0	-0.1	0.000
2:15:40 PM	26.2	26.4	8.2	8.2	0.0	-0.1	0.000
2:16:40 PM	26.2	26.4	8.2	8.2	0.0	-0.1	0.000
2:17:40 PM	26.2	26.4	8.2	8.2	0.0	-0.1	0.000
2:18:40 PM	26.2	26.5	7.3	2.5	-4.8	0.8	-2.368
2:19:40 PM	26.3	26.5	1.6	0.3	-1.3	6.5	-0.641
2:20:40 PM	26.3	26.5	1.0	0.2	-0.8	7.1	-0.395
2:21:40 PM	26.3	26.5	0.6	0.2	-0.4	7.5	-0.197
2:22:40 PM	26.3	26.5	0.3	0.1	-0.2	7.8	-0.099
2:23:40 PM	26.3	26.5	0.1	0.1	0.0	8.0	0.000
2:24:40 PM	26.3	26.5	0.1	0.4	0.3	8.0	0.148
2:25:40 PM	26.3	26.5	0.2	0.9	0.7	7.9	0.345
2:26:40 PM	26.3	26.5	0.3	1.1	0.8	7.8	0.395
2:27:40 PM	26.3	26.5	0.5	1.4	0.9	7.6	0.444
2:28:40 PM	26.3	26.5	0.7	1.6	0.9	7.4	0.444
2:29:40 PM	26.3	26.5	0.8	1.9	1.1	7.3	0.543
2:30:40 PM	26.3	26.5	1.0	2.1	1.1	7.1	0.543
2:31:40 PM	26.3	26.5	1.3	2.3	1.0	6.8	0.493
2:32:40 PM	26.3	26.5	1.5	2.5	1.0	6.6	0.493

15.2 cm air-lift_Trial 1_7/16/2007 (continued)

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		$C_{out} - C_t$	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
2:33:40 PM	26.3	26.5	1.7	2.7	1.0	6.4	0.493
2:34:40 PM	26.3	26.5	2.0	2.9	0.9	6.1	0.444
2:35:40 PM	26.3	26.5	2.1	3.1	1.0	6.0	0.493
2:36:40 PM	26.3	26.5	2.3	3.3	1.0	5.8	0.493
2:37:40 PM	26.3	26.5	2.5	3.5	1.0	5.6	0.493
2:38:40 PM	26.3	26.5	2.7	3.6	0.9	5.4	0.444
2:39:40 PM	26.3	26.5	2.9	3.8	0.9	5.2	0.444
2:40:40 PM	26.3	26.5	3.1	4.0	0.9	5.0	0.444
2:41:40 PM	26.3	26.5	3.2	4.1	0.9	4.9	0.444
2:42:40 PM	26.3	26.5	3.4	4.3	0.9	4.7	0.444
2:43:40 PM	26.3	26.5	3.6	4.4	0.8	4.5	0.395
2:44:41 PM	26.3	26.5	3.7	4.4	0.7	4.4	0.345
2:45:41 PM	26.3	26.5	3.9	4.6	0.7	4.2	0.345
2:46:41 PM	26.3	26.5	4.1	4.8	0.7	4.0	0.345
2:47:41 PM	26.3	26.5	4.3	4.9	0.6	3.8	0.296
2:48:41 PM	26.3	26.5	4.5	5.0	0.5	3.6	0.247
2:49:41 PM	26.3	26.5	4.5	5.1	0.6	3.6	0.296
2:50:41 PM	26.3	26.5	4.7	5.2	0.5	3.4	0.247
2:51:41 PM	26.3	26.5	4.8	5.3	0.5	3.3	0.247
2:52:41 PM	26.3	26.5	4.9	5.4	0.5	3.2	0.247
2:53:41 PM	26.3	26.5	5.0	5.5	0.5	3.1	0.247
2:54:41 PM	26.3	26.5	5.1	5.6	0.5	3.0	0.247
2:55:41 PM	26.3	26.5	5.2	5.7	0.5	2.9	0.247
2:56:41 PM	26.3	26.5	5.3	5.8	0.5	2.8	0.247
2:57:41 PM	26.3	26.5	5.4	5.8	0.4	2.7	0.197
2:58:41 PM	26.3	26.5	5.5	5.9	0.4	2.6	0.197
2:59:41 PM	26.3	26.5	5.6	6.0	0.4	2.5	0.197
3:00:41 PM	26.3	26.5	5.7	6.1	0.4	2.4	0.197
3:01:41 PM	26.3	26.5	5.7	6.2	0.5	2.4	0.247
3:02:41 PM	26.3	26.5	5.9	6.2	0.3	2.2	0.148
3:03:41 PM	26.3	26.5	5.9	6.3	0.4	2.2	0.197
3:04:41 PM	26.3	26.5	6.0	6.4	0.4	2.1	0.197
3:05:41 PM	26.3	26.5	6.1	6.4	0.3	2.0	0.148
3:06:41 PM	26.3	26.5	6.1	6.5	0.4	2.0	0.197
3:07:41 PM	26.3	26.5	6.2	6.5	0.3	1.9	0.148

15.2 cm air-lift_Trial 1_7/16/2007 (continued)

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		$C_{out} - C_t$	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
3:08:41 PM	26.3	26.5	6.3	6.6	0.3	1.8	0.148
3:09:41 PM	26.3	26.5	6.4	6.7	0.3	1.7	0.148
3:10:41 PM	26.3	26.5	6.4	6.7	0.3	1.7	0.148
3:11:41 PM	26.3	26.5	6.5	6.7	0.2	1.6	0.099
3:12:41 PM	26.3	26.5	6.5	6.8	0.3	1.6	0.148
3:13:41 PM	26.3	26.5	6.6	6.9	0.3	1.5	0.148
3:14:42 PM	26.3	26.5	6.6	6.9	0.3	1.5	0.148
3:15:42 PM	26.3	26.5	6.7	7.0	0.3	1.4	0.148
3:16:42 PM	26.3	26.5	6.8	7.0	0.2	1.3	0.099
3:17:42 PM	26.3	26.5	6.8	7.0	0.2	1.3	0.099
3:18:42 PM	26.3	26.5	6.8	7.0	0.2	1.3	0.099
3:19:42 PM	26.3	26.5	6.9	7.1	0.2	1.2	0.099
3:20:42 PM	26.3	26.5	6.9	7.1	0.2	1.2	0.099
3:21:42 PM	26.3	26.5	6.9	7.1	0.2	1.2	0.099
3:22:42 PM	26.3	26.5	7.0	7.2	0.2	1.1	0.099
3:23:42 PM	26.3	26.5	7.1	7.2	0.1	1.0	0.049
3:24:42 PM	26.3	26.5	7.1	7.3	0.2	1.0	0.099
3:25:42 PM	26.3	26.5	7.1	7.3	0.2	1.0	0.099
3:26:42 PM	26.3	26.5	7.2	7.3	0.1	0.9	0.049
3:27:42 PM	26.3	26.5	7.2	7.3	0.1	0.9	0.049
3:28:42 PM	26.3	26.5	7.2	7.4	0.2	0.9	0.099
3:29:42 PM	26.3	26.5	7.3	7.4	0.1	0.8	0.049
3:30:42 PM	26.3	26.5	7.3	7.4	0.1	0.8	0.049
3:31:42 PM	26.4	26.5	7.3	7.5	0.2	0.8	0.099
3:32:42 PM	26.4	26.5	7.3	7.5	0.2	0.8	0.099
3:33:42 PM	26.3	26.5	7.4	7.5	0.1	0.7	0.049
3:34:42 PM	26.4	26.5	7.4	7.5	0.1	0.7	0.049
3:35:42 PM	26.4	26.5	7.4	7.6	0.2	0.7	0.099
3:36:42 PM	26.4	26.5	7.4	7.6	0.2	0.7	0.099
3:37:42 PM	26.4	26.5	7.5	7.6	0.1	0.6	0.049
3:38:42 PM	26.4	26.5	7.5	7.6	0.1	0.6	0.049
3:39:42 PM	26.4	26.5	7.5	7.6	0.1	0.6	0.049
3:40:42 PM	26.4	26.5	7.5	7.7	0.2	0.6	0.099
3:41:42 PM	26.4	26.5	7.6	7.7	0.1	0.5	0.049

15.2 cm air-lift_Trial 2_7/22/2007

Hydraulic Summary

Time	Volume [liters]	Fill time [sec]	Q_L [l min^{-1}]
12:00 PM	20.06	3.50	343.89
12:15 PM	20.06	3.62	332.49
1:15 PM	20.06	3.56	338.09

Lift	**30.5**	**cm**	$Q_{L,ave}$	**338.15**	**l min^{-1}**
Salinity	**1**	**ppt**	$Q_{G,ave}$	**340.00**	**l min^{-1}**
C_s	**8.20**	**mg l^{-1}**	Q_G:Q_L	**1.01**	
V_{tank}	**7973**	**liters**			

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		C_{out} - C_t	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
11:57:55 AM	26.8	25	8.2	8.4	0.2	0.0	0.097
11:58:25 AM	26.8	25	8.2	8.4	0.2	0.0	0.097
11:58:55 AM	26.8	25	8.2	8.4	0.2	0.0	0.097
11:59:25 AM	26.7	25	8.2	8.4	0.2	0.0	0.097
11:59:55 AM	26.7	25	8.2	8.4	0.2	0.0	0.097
12:00:25 PM	26.8	25	0.4	7.4	7.0	7.8	3.409
12:00:55 PM	26.7	25	0.2	6.3	6.1	8.0	2.970
12:01:25 PM	26.7	25	0.2	3.7	3.5	8.0	1.704
12:01:55 PM	26.7	25	0.9	1.3	0.4	7.3	0.195
12:02:25 PM	26.7	25	2.9	0.5	-2.4	5.3	-1.169
12:02:55 PM	26.7	25	2.0	0.2	-1.8	6.2	-0.876
12:03:25 PM	26.7	25	0.1	0.3	0.2	8.1	0.097
12:03:55 PM	26.7	25	0.1	0.5	0.4	8.1	0.195
12:04:25 PM	26.7	25	0.1	0.5	0.4	8.1	0.195
12:04:55 PM	26.7	25	0.1	0.2	0.1	8.1	0.049
12:05:25 PM	26.7	25	0.1	0.3	0.2	8.1	0.097
12:05:55 PM	26.7	25	0.1	0.3	0.2	8.1	0.097
12:06:25 PM	26.6	25	0.4	0.0	-0.4	7.8	-0.195
12:06:55 PM	26.7	25	0.8	0.0	-0.8	7.4	-0.390
12:07:26 PM	26.6	25	0.3	0.1	-0.2	7.9	-0.097
12:07:55 PM	26.6	25	0.3	0.2	-0.1	7.9	-0.049
12:08:25 PM	26.6	25	0.2	0.3	0.1	8.0	0.049
12:08:56 PM	26.6	25	0.4	0.4	0.0	7.8	0.000

15.2 cm air-lift_Trial 2_7/22/2007 (continued)

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		$C_{out} - C_t$	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
12:09:25 PM	26.6	25	0.5	0.5	0.0	7.7	0.000
12:09:55 PM	26.6	25	0.5	0.4	-0.1	7.7	-0.049
12:10:25 PM	26.6	25	0.4	0.4	0.0	7.8	0.000
12:10:55 PM	26.6	25	0.5	0.6	0.1	7.7	0.049
12:11:25 PM	26.6	25	0.4	0.8	0.4	7.8	0.195
12:11:55 PM	26.5	25	0.4	0.9	0.5	7.8	0.243
12:12:27 PM	26.5	25	0.4	1.1	0.7	7.8	0.341
12:12:57 PM	26.6	25	0.4	1.3	0.9	7.8	0.438
12:13:27 PM	26.5	25	0.5	1.5	1.0	7.7	0.487
12:13:57 PM	26.5	25	0.5	1.6	1.1	7.7	0.536
12:14:27 PM	26.5	25	0.6	1.8	1.2	7.6	0.584
12:14:57 PM	26.5	25	0.7	1.9	1.2	7.5	0.584
12:15:27 PM	26.5	25	0.8	2.0	1.2	7.4	0.584
12:15:57 PM	26.5	25	0.9	2.1	1.2	7.3	0.584
12:16:27 PM	26.5	25	1.1	2.3	1.2	7.1	0.584
12:16:57 PM	26.5	25	1.2	2.4	1.2	7.0	0.584
12:17:27 PM	26.5	25	1.3	2.4	1.1	6.9	0.536
12:17:57 PM	26.5	25	1.4	2.6	1.2	6.8	0.584
12:18:27 PM	26.5	25	1.5	2.9	1.4	6.7	0.682
12:18:57 PM	26.4	25	1.7	2.9	1.2	6.5	0.584
12:19:27 PM	26.4	25	1.8	3.0	1.2	6.4	0.584
12:19:57 PM	26.4	25	1.9	3.1	1.2	6.3	0.584
12:20:27 PM	26.4	25	2.0	3.2	1.2	6.2	0.584
12:20:57 PM	26.4	25	2.2	3.3	1.1	6.0	0.536
12:21:27 PM	26.4	25	2.3	3.4	1.1	5.9	0.536
12:21:57 PM	26.4	25	2.4	3.6	1.2	5.8	0.584
12:22:27 PM	26.4	25	2.5	3.7	1.2	5.7	0.584
12:22:57 PM	26.4	25	2.6	3.8	1.2	5.6	0.584
12:23:27 PM	26.4	25	2.7	3.9	1.2	5.5	0.584
12:23:57 PM	26.4	25	2.8	3.9	1.1	5.4	0.536
12:24:27 PM	26.4	25	2.9	4.0	1.1	5.3	0.536
12:24:57 PM	26.4	25	3.1	4.1	1.0	5.1	0.487
12:25:27 PM	26.4	25	3.2	4.2	1.0	5.0	0.487
12:25:57 PM	26.4	25	3.3	4.3	1.0	4.9	0.487
12:26:27 PM	26.4	25	3.3	4.3	1.0	4.9	0.487

15.2 cm air-lift_Trial 2_7/22/2007 (continued)

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		$C_{out} - C_t$	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
12:26:57 PM	26.4	25	3.4	4.4	1.0	4.8	0.487
12:27:28 PM	26.4	25	3.6	4.5	0.9	4.6	0.438
12:27:58 PM	26.4	25	3.6	4.6	1.0	4.6	0.487
12:28:28 PM	26.4	25	3.7	4.6	0.9	4.5	0.438
12:28:58 PM	26.4	25	3.8	4.6	0.8	4.4	0.390
12:29:28 PM	26.4	25	3.9	4.7	0.8	4.3	0.390
12:29:58 PM	26.4	25	4.0	4.8	0.8	4.2	0.390
12:30:28 PM	26.4	25	4.1	4.9	0.8	4.1	0.390
12:30:58 PM	26.3	25	4.2	4.9	0.7	4.0	0.341
12:31:28 PM	26.4	25	4.2	5.0	0.8	4.0	0.390
12:31:58 PM	26.4	25	4.3	5.1	0.8	3.9	0.390
12:32:28 PM	26.4	25	4.4	5.2	0.8	3.8	0.390
12:32:58 PM	26.4	25	4.5	5.2	0.7	3.7	0.341
12:33:28 PM	26.3	25	4.6	5.3	0.7	3.6	0.341
12:33:58 PM	26.3	25	4.6	5.4	0.8	3.6	0.390
12:34:28 PM	26.3	25	4.7	5.4	0.7	3.5	0.341
12:34:58 PM	26.3	25	4.8	5.4	0.6	3.4	0.292
12:35:28 PM	26.3	25	4.8	5.5	0.7	3.4	0.341
12:35:58 PM	26.4	25	4.9	5.6	0.7	3.3	0.341
12:36:28 PM	26.3	25	5.0	5.6	0.6	3.2	0.292
12:36:58 PM	26.4	25	5.0	5.7	0.7	3.2	0.341
12:37:28 PM	26.4	25	5.1	5.7	0.6	3.1	0.292
12:37:58 PM	26.3	25	5.2	5.8	0.6	3.0	0.292
12:38:28 PM	26.3	25	5.2	5.9	0.7	3.0	0.341
12:38:58 PM	26.3	25	5.3	5.9	0.6	2.9	0.292
12:39:28 PM	26.3	25	5.3	5.9	0.6	2.9	0.292
12:39:58 PM	26.3	25	5.4	6.0	0.6	2.8	0.292
12:40:28 PM	26.3	25	5.4	6.0	0.6	2.8	0.292
12:40:58 PM	26.3	25	5.5	6.0	0.5	2.7	0.243
12:41:30 PM	26.3	25	5.6	6.1	0.5	2.6	0.243
12:41:59 PM	26.3	25	5.6	6.2	0.6	2.6	0.292
12:42:30 PM	26.3	25	5.7	6.2	0.5	2.5	0.243
12:42:59 PM	26.3	25	5.7	6.3	0.6	2.5	0.292
12:43:30 PM	26.3	25	5.7	6.3	0.6	2.5	0.292
12:43:59 PM	26.3	25	5.8	6.3	0.5	2.4	0.243

15.2 cm air-lift_Trial 2_7/22/2007 (continued)

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		C_{out} - C_t	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
12:44:30 PM	26.3	25	5.9	6.3	0.4	2.3	0.195
12:45:00 PM	26.3	25	5.9	6.4	0.5	2.3	0.243
12:45:29 PM	26.3	25	6.0	6.4	0.4	2.2	0.195
12:46:00 PM	26.3	25	6.0	6.5	0.5	2.2	0.243
12:46:29 PM	26.3	25	6.0	6.5	0.5	2.2	0.243
12:47:00 PM	26.3	25	6.1	6.5	0.4	2.1	0.195
12:47:29 PM	26.2	25	6.1	6.6	0.5	2.1	0.243
12:48:00 PM	26.3	25	6.2	6.6	0.4	2.0	0.195
12:48:29 PM	26.3	25	6.2	6.6	0.4	2.0	0.195
12:49:00 PM	26.3	25	6.2	6.7	0.5	2.0	0.243
12:49:29 PM	26.2	25	6.3	6.7	0.4	1.9	0.195
12:50:00 PM	26.2	25	6.4	6.7	0.3	1.8	0.146
12:50:29 PM	26.3	25.1	6.4	6.8	0.4	1.8	0.195
12:51:00 PM	26.3	25.1	6.4	6.8	0.4	1.8	0.195
12:51:29 PM	26.3	25.1	6.5	6.8	0.3	1.7	0.146
12:52:00 PM	26.2	25.1	6.5	6.9	0.4	1.7	0.195
12:52:30 PM	26.2	25.1	6.5	6.9	0.4	1.7	0.195
12:52:59 PM	26.3	25.1	6.6	6.9	0.3	1.6	0.146
12:53:30 PM	26.3	25.1	6.6	7.0	0.4	1.6	0.195
12:53:59 PM	26.3	25.1	6.6	7.0	0.4	1.6	0.195
12:54:31 PM	26.3	25.1	6.7	7.0	0.3	1.5	0.146
12:55:01 PM	26.3	25.1	6.7	7.0	0.3	1.5	0.146
12:55:31 PM	26.3	25.1	6.7	7.0	0.3	1.5	0.146
12:56:01 PM	26.3	25.1	6.8	7.1	0.3	1.4	0.146
12:56:31 PM	26.2	25.1	6.8	7.1	0.3	1.4	0.146
12:57:01 PM	26.2	25.1	6.8	7.1	0.3	1.4	0.146
12:57:31 PM	26.3	25.1	6.8	7.2	0.4	1.4	0.195
12:58:01 PM	26.2	25.1	6.9	7.2	0.3	1.3	0.146
12:58:31 PM	26.3	25.1	6.9	7.2	0.3	1.3	0.146
12:59:01 PM	26.3	25.1	6.9	7.2	0.3	1.3	0.146
12:59:31 PM	26.3	25.1	7.0	7.2	0.2	1.2	0.097
1:00:01 PM	26.2	25.1	7.0	7.3	0.3	1.2	0.146
1:00:31 PM	26.3	25.1	7.0	7.3	0.3	1.2	0.146
1:01:01 PM	26.2	25.1	7.0	7.3	0.3	1.2	0.146
1:01:31 PM	26.2	25.1	7.1	7.3	0.2	1.1	0.097

15.2 cm air-lift_Trial 2_7/22/2007 (continued)

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		$C_{out} - C_t$	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
1:02:01 PM	26.2	25.1	7.1	7.3	0.2	1.1	0.097
1:02:31 PM	26.3	25.1	7.1	7.4	0.3	1.1	0.146
1:03:01 PM	26.2	25.1	7.1	7.4	0.3	1.1	0.146
1:03:31 PM	26.2	25.1	7.2	7.4	0.2	1.0	0.097
1:04:01 PM	26.2	25.1	7.2	7.4	0.2	1.0	0.097
1:04:31 PM	26.2	25.1	7.2	7.4	0.2	1.0	0.097
1:05:01 PM	26.2	25.1	7.2	7.5	0.3	1.0	0.146
1:05:31 PM	26.2	25.1	7.3	7.5	0.2	0.9	0.097
1:06:01 PM	26.2	25.1	7.3	7.5	0.2	0.9	0.097
1:06:31 PM	26.2	25.1	7.3	7.5	0.2	0.9	0.097
1:07:01 PM	26.2	25.1	7.3	7.5	0.2	0.9	0.097
1:07:32 PM	26.2	25.1	7.3	7.5	0.2	0.9	0.097
1:08:02 PM	26.2	25.1	7.4	7.6	0.2	0.8	0.097
1:08:32 PM	26.2	25.1	7.4	7.6	0.2	0.8	0.097
1:09:02 PM	26.2	25.1	7.4	7.6	0.2	0.8	0.097
1:09:32 PM	26.2	25.1	7.4	7.6	0.2	0.8	0.097
1:10:02 PM	26.2	25.1	7.4	7.6	0.2	0.8	0.097
1:10:32 PM	26.2	25.1	7.5	7.6	0.1	0.7	0.049
1:11:02 PM	26.2	25.1	7.5	7.7	0.2	0.7	0.097
1:11:32 PM	26.2	25.1	7.5	7.7	0.2	0.7	0.097
1:12:02 PM	26.2	25.1	7.5	7.7	0.2	0.7	0.097
1:12:32 PM	26.2	25.1	7.5	7.7	0.2	0.7	0.097
1:13:02 PM	26.2	25.1	7.6	7.7	0.1	0.6	0.049
1:13:32 PM	26.2	25.1	7.6	7.7	0.1	0.6	0.049
1:14:02 PM	26.2	25.1	7.6	7.7	0.1	0.6	0.049
1:14:32 PM	26.2	25.1	7.6	7.7	0.1	0.6	0.049
1:15:02 PM	26.2	25.1	7.6	7.8	0.2	0.6	0.097
1:15:32 PM	26.2	25.1	7.6	7.8	0.2	0.6	0.097
1:16:02 PM	26.2	25.1	7.6	7.8	0.2	0.6	0.097
1:16:32 PM	26.2	25.1	7.7	7.8	0.1	0.5	0.049
1:17:02 PM	26.2	25.1	7.7	7.8	0.1	0.5	0.049
1:17:32 PM	26.2	25.1	7.7	7.8	0.1	0.5	0.049
1:18:02 PM	26.2	25.1	7.7	7.8	0.1	0.5	0.049
1:18:32 PM	26.2	25.1	7.7	7.8	0.1	0.5	0.049

15.2 cm air-lift_Trial 3_7/22/2007

Hydraulic Summary

Time	Volume [liters]	Fill time [sec]	Q_L [l min^{-1}]
1:45 PM	20.06	3.62	332.49
2:15 PM	20.06	3.58	336.20
2:45 PM	20.06	3.60	334.33
3:15 PM	20.06	3.45	348.87

Lift	**30.5**	**cm**	$Q_{L,ave}$	**337.97**	**l min^{-1}**
Salinity	**1**	**ppt**	$Q_{G,ave}$	**340.00**	**l min^{-1}**
C_s	**8.20**	**mg l^{-1}**	Q_G:Q_L	**1.01**	
V_{tank}	**7973**	**liters**			

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		C_{out} - C_t	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
1:51:05 PM	26.1	25.1	8.2	8.2	0.0	0.0	0.000
1:51:35 PM	26.1	25.1	8.2	8.2	0.0	0.0	0.000
1:52:05 PM	26.1	25.1	8.2	8.3	0.1	0.0	0.049
1:52:35 PM	26.1	25.1	8.2	8.2	0.0	0.0	0.000
1:53:05 PM	26.1	25.1	8.3	8.2	-0.1	-0.1	-0.049
1:53:35 PM	26.1	25.1	8.2	8.3	0.1	0.0	0.049
1:54:05 PM	26.1	25.1	0.3	8.3	8.0	7.9	3.893
1:54:35 PM	26.1	25.1	0.2	7.2	7.0	8.0	3.407
1:55:05 PM	26.1	25.1	0.1	4.6	4.5	8.1	2.190
1:55:35 PM	26.1	25.1	0.1	3.6	3.5	8.1	1.703
1:56:05 PM	26.1	25.1	0.1	3.4	3.3	8.1	1.606
1:56:35 PM	26.1	25.1	0.1	3.4	3.3	8.1	1.606
1:57:05 PM	26.1	25.1	0.1	2.9	2.8	8.1	1.363
1:57:35 PM	26.1	25.1	0.1	2.5	2.4	8.1	1.168
1:58:05 PM	26.1	25.1	0.1	2.7	2.6	8.1	1.265
1:58:35 PM	26.2	25.1	0.1	2.5	2.4	8.1	1.168
1:59:07 PM	26.2	25.1	0.1	2.3	2.2	8.1	1.071
1:59:37 PM	26.1	25.1	0.1	2.0	1.9	8.1	0.925
2:00:07 PM	26.2	25.1	0.1	1.0	0.9	8.1	0.438
2:00:37 PM	26.2	25.1	0.1	1.9	1.8	8.1	0.876
2:01:07 PM	26.1	25.2	0.1	1.4	1.3	8.1	0.633
2:01:37 PM	26.2	25.2	0.1	0.1	0.0	8.1	0.000

15.2 cm air-lift_Trial 3_7/22/2007 (continued)

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		$C_{out} - C_t$	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
2:02:07 PM	26.1	25.2	0.1	0.1	0.0	8.1	0.000
2:02:37 PM	26.2	25.2	0.1	0.0	-0.1	8.1	-0.049
2:03:07 PM	26.1	25.2	0.1	0.0	-0.1	8.1	-0.049
2:03:37 PM	26.1	25.2	0.1	0.0	-0.1	8.1	-0.049
2:04:07 PM	26.1	25.2	0.1	0.0	-0.1	8.1	-0.049
2:04:37 PM	26.1	25.2	0.1	0.0	-0.1	8.1	-0.049
2:05:07 PM	26.1	25.2	0.1	0.0	-0.1	8.1	-0.049
2:05:37 PM	26.1	25.2	0.1	0.1	0.0	8.1	0.000
2:06:07 PM	26.1	25.2	0.1	0.2	0.1	8.1	0.049
2:06:37 PM	26.1	25.2	0.1	0.5	0.4	8.1	0.195
2:07:07 PM	26.1	25.2	0.1	0.8	0.7	8.1	0.341
2:07:37 PM	26.1	25.2	0.1	0.8	0.7	8.1	0.341
2:08:07 PM	26.2	25.2	0.1	0.9	0.8	8.1	0.389
2:08:38 PM	26.2	25.2	0.1	1.1	1.0	8.1	0.487
2:09:08 PM	26.1	25.2	0.2	1.3	1.1	8.0	0.535
2:09:38 PM	26.1	25.2	0.3	1.4	1.1	7.9	0.535
2:10:08 PM	26.1	25.2	0.3	1.5	1.2	7.9	0.584
2:10:38 PM	26.1	25.2	0.5	1.6	1.1	7.7	0.535
2:11:08 PM	26.1	25.2	0.6	1.8	1.2	7.6	0.584
2:11:38 PM	26.1	25.2	0.7	1.9	1.2	7.5	0.584
2:12:08 PM	26.1	25.2	0.9	2.1	1.2	7.3	0.584
2:12:38 PM	26.1	25.2	1.0	2.2	1.2	7.2	0.584
2:13:08 PM	26.1	25.2	1.1	2.3	1.2	7.1	0.584
2:13:38 PM	26.1	25.2	1.3	2.5	1.2	6.9	0.584
2:14:08 PM	26.1	25.2	1.4	2.6	1.2	6.8	0.584
2:14:38 PM	26.2	25.2	1.6	2.7	1.1	6.6	0.535
2:15:08 PM	26.2	25.2	1.7	2.8	1.1	6.5	0.535
2:15:38 PM	26.2	25.2	1.8	3.0	1.2	6.4	0.584
2:16:08 PM	26.2	25.2	2.0	3.1	1.1	6.2	0.535
2:16:38 PM	26.2	25.2	2.1	3.1	1.0	6.1	0.487
2:17:08 PM	26.2	25.2	2.2	3.2	1.0	6.0	0.487
2:17:38 PM	26.2	25.2	2.4	3.4	1.0	5.8	0.487
2:18:09 PM	26.2	25.2	2.6	3.4	0.8	5.6	0.389
2:18:39 PM	26.1	25.2	2.7	3.5	0.8	5.5	0.389
2:19:09 PM	26.2	25.2	2.8	3.6	0.8	5.4	0.389

15.2 cm air-lift_Trial 3_7/22/2007 (continued)

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		$C_{out} - C_t$	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
2:19:39 PM	26.2	25.2	2.9	3.7	0.8	5.3	0.389
2:20:09 PM	26.2	25.2	3.0	3.8	0.8	5.2	0.389
2:20:39 PM	26.1	25.2	3.2	3.9	0.7	5.0	0.341
2:21:09 PM	26.2	25.2	3.2	3.9	0.7	5.0	0.341
2:21:39 PM	26.1	25.2	3.4	4.1	0.7	4.8	0.341
2:22:09 PM	26.1	25.2	3.4	4.2	0.8	4.8	0.389
2:22:39 PM	26.2	25.2	3.5	4.3	0.8	4.7	0.389
2:23:09 PM	26.2	25.2	3.6	4.4	0.8	4.6	0.389
2:23:39 PM	26.1	25.2	3.7	4.4	0.7	4.5	0.341
2:24:09 PM	26.1	25.2	3.8	4.5	0.7	4.4	0.341
2:24:39 PM	26.2	25.2	3.9	4.6	0.7	4.3	0.341
2:25:09 PM	26.2	25.2	4.0	4.7	0.7	4.2	0.341
2:25:39 PM	26.1	25.2	4.0	4.8	0.8	4.2	0.389
2:26:09 PM	26.2	25.2	4.1	4.8	0.7	4.1	0.341
2:26:39 PM	26.2	25.2	4.2	4.9	0.7	4.0	0.341
2:27:11 PM	26.2	25.2	4.3	4.9	0.6	3.9	0.292
2:27:41 PM	26.2	25.2	4.3	5.0	0.7	3.9	0.341
2:28:11 PM	26.2	25.2	4.4	5.1	0.7	3.8	0.341
2:28:41 PM	26.2	25.2	4.5	5.1	0.6	3.7	0.292
2:29:11 PM	26.2	25.2	4.6	5.2	0.6	3.6	0.292
2:29:41 PM	26.2	25.2	4.6	5.3	0.7	3.6	0.341
2:30:11 PM	26.1	25.2	4.7	5.4	0.7	3.5	0.341
2:30:41 PM	26.1	25.2	4.8	5.4	0.6	3.4	0.292
2:31:11 PM	26.1	25.2	4.9	5.4	0.5	3.3	0.243
2:31:41 PM	26.1	25.2	4.9	5.5	0.6	3.3	0.292
2:32:11 PM	26.1	25.2	5.0	5.6	0.6	3.2	0.292
2:32:41 PM	26.1	25.2	5.1	5.6	0.5	3.1	0.243
2:33:11 PM	26.2	25.2	5.1	5.6	0.5	3.1	0.243
2:33:41 PM	26.1	25.2	5.2	5.7	0.5	3.0	0.243
2:34:11 PM	26.1	25.2	5.2	5.8	0.6	3.0	0.292
2:34:41 PM	26.2	25.2	5.3	5.8	0.5	2.9	0.243
2:35:11 PM	26.1	25.2	5.3	5.8	0.5	2.9	0.243
2:35:42 PM	26.2	25.2	5.4	5.9	0.5	2.8	0.243
2:36:12 PM	26.2	25.2	5.5	5.9	0.4	2.7	0.195
2:36:42 PM	26.2	25.2	5.5	6.0	0.5	2.7	0.243

15.2 cm air-lift_Trial 3_7/22/2007 (continued)

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		$C_{out} - C_t$	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
2:37:12 PM	26.2	25.2	5.6	6.1	0.5	2.6	0.243
2:37:42 PM	26.2	25.2	5.6	6.1	0.5	2.6	0.243
2:38:12 PM	26.2	25.2	5.7	6.1	0.4	2.5	0.195
2:38:42 PM	26.2	25.2	5.7	6.2	0.5	2.5	0.243
2:39:12 PM	26.1	25.2	5.8	6.2	0.4	2.4	0.195
2:39:42 PM	26.2	25.2	5.8	6.2	0.4	2.4	0.195
2:40:12 PM	26.2	25.2	5.9	6.3	0.4	2.3	0.195
2:40:42 PM	26.1	25.2	5.9	6.3	0.4	2.3	0.195
2:41:12 PM	26.1	25.2	6.0	6.3	0.3	2.2	0.146
2:41:42 PM	26.2	25.2	6.1	6.4	0.3	2.1	0.146
2:42:12 PM	26.2	25.2	6.1	6.4	0.3	2.1	0.146
2:42:42 PM	26.2	25.2	6.1	6.5	0.4	2.1	0.195
2:43:12 PM	26.1	25.2	6.2	6.5	0.3	2.0	0.146
2:43:43 PM	26.1	25.2	6.2	6.5	0.3	2.0	0.146
2:44:14 PM	26.1	25.2	6.3	6.6	0.3	1.9	0.146
2:44:43 PM	26.1	25.2	6.3	6.6	0.3	1.9	0.146
2:45:14 PM	26.1	25.2	6.3	6.6	0.3	1.9	0.146
2:45:43 PM	26.1	25.2	6.4	6.7	0.3	1.8	0.146
2:46:14 PM	26.1	25.2	6.4	6.7	0.3	1.8	0.146
2:46:43 PM	26.1	25.2	6.4	6.8	0.4	1.8	0.195
2:47:14 PM	26.1	25.2	6.5	6.8	0.3	1.7	0.146
2:47:43 PM	26.1	25.2	6.5	6.8	0.3	1.7	0.146
2:48:14 PM	26.1	25.2	6.6	6.8	0.2	1.6	0.097
2:48:43 PM	26.1	25.2	6.6	6.9	0.3	1.6	0.146
2:49:14 PM	26.1	25.2	6.6	6.9	0.3	1.6	0.146
2:49:43 PM	26.1	25.2	6.7	6.9	0.2	1.5	0.097
2:50:14 PM	26.1	25.2	6.7	7.0	0.3	1.5	0.146
2:50:43 PM	26.1	25.2	6.7	7.0	0.3	1.5	0.146
2:51:15 PM	26.1	25.2	6.8	7.0	0.2	1.4	0.097
2:51:45 PM	26.2	25.2	6.8	7.0	0.2	1.4	0.097
2:52:15 PM	26.1	25.2	6.8	7.1	0.3	1.4	0.146
2:52:45 PM	26.1	25.2	6.8	7.1	0.3	1.4	0.146
2:53:15 PM	26.2	25.2	6.9	7.1	0.2	1.3	0.097
2:53:45 PM	26.2	25.2	6.9	7.1	0.2	1.3	0.097
2:54:15 PM	26.2	25.2	6.9	7.2	0.3	1.3	0.146

15.2 cm air-lift_Trial 3_7/22/2007 (continued)

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		$C_{out} - C_t$	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
2:54:45 PM	26.2	25.2	7.0	7.2	0.2	1.2	0.097
2:55:15 PM	26.2	25.2	7.0	7.2	0.2	1.2	0.097
2:55:45 PM	26.1	25.2	7.0	7.2	0.2	1.2	0.097
2:56:15 PM	26.1	25.2	7.0	7.2	0.2	1.2	0.097
2:56:45 PM	26.1	25.2	7.1	7.3	0.2	1.1	0.097
2:57:15 PM	26.1	25.2	7.1	7.3	0.2	1.1	0.097
2:57:45 PM	26.2	25.2	7.1	7.3	0.2	1.1	0.097
2:58:16 PM	26.2	25.2	7.1	7.3	0.2	1.1	0.097
2:58:46 PM	26.1	25.2	7.2	7.3	0.1	1.0	0.049
2:59:16 PM	26.1	25.2	7.2	7.4	0.2	1.0	0.097
2:59:46 PM	26.1	25.2	7.2	7.4	0.2	1.0	0.097
3:00:16 PM	26.2	25.2	7.2	7.4	0.2	1.0	0.097
3:00:46 PM	26.2	25.2	7.3	7.4	0.1	0.9	0.049
3:01:16 PM	26.2	25.2	7.3	7.4	0.1	0.9	0.049
3:01:46 PM	26.1	25.2	7.3	7.4	0.1	0.9	0.049
3:02:16 PM	26.1	25.2	7.3	7.5	0.2	0.9	0.097
3:02:46 PM	26.1	25.2	7.3	7.5	0.2	0.9	0.097
3:03:16 PM	26.1	25.2	7.4	7.5	0.1	0.8	0.049
3:03:46 PM	26.1	25.2	7.4	7.5	0.1	0.8	0.049
3:04:16 PM	26.1	25.2	7.4	7.5	0.1	0.8	0.049
3:04:46 PM	26.1	25.2	7.4	7.6	0.2	0.8	0.097
3:05:17 PM	26.1	25.2	7.4	7.6	0.2	0.8	0.097
3:05:48 PM	26.1	25.2	7.5	7.6	0.1	0.7	0.049
3:06:17 PM	26.2	25.2	7.5	7.6	0.1	0.7	0.049
3:06:48 PM	26.2	25.2	7.5	7.6	0.1	0.7	0.049
3:07:17 PM	26.2	25.2	7.5	7.6	0.1	0.7	0.049

OTR and $C_{deficit}$ Linear Regression Summary at 340 l min^{-1} air injection

Air-lift [cm]	Trial	Lift [cm]	OTR Coefficient for $C_{deficit}$ equations	R^2
15.2	1	30.5	OTR =0.0788*$C_{deficit}$	0.971
15.2	2	30.5	OTR = 0.0894*$C_{deficit}$	0.968
15.2	3	30.5	OTR = 0.0811*$C_{deficit}$	0.966

K_La and SOTR Summary for 340 l min^{-1} air injection

		K_La [min^{-1}]		K_La_{20} [min^{-1}]		SOTR [kg hr^{-1}]	
Air-lift [cm]	**Trial**	**Inlet**	**Outlet**	**Inlet**	**Outlet**	**Inlet**	**Outlet**
15.2	1	0.037	0.037	0.031	0.031	0.1376	0.1376
15.2	2	0.042	0.042	0.036	0.037	0.1574	0.1593
15.2	3	0.042	0.042	0.037	0.037	0.1589	0.1589
	Ave	**0.040**	**0.040**	**0.035**	**0.035**	**0.1513**	**0.1519**
	St. D.	**0.003**	**0.003**	**0.003**	**0.003**	**0.0119**	**0.0124**

AERATION STUDIES (continued)

15.2 cm air-lift_495 l air min^{-1}

15.2 cm air-lift_Trial 1_7/19/2007

Hydraulic Summary

Time	Volume [liters]	Fill time [sec]	Q_L [l min^{-1}]
2:00 PM	20.06	3.56	338.09
2:30 PM	20.06	3.50	343.89
3:00 PM	20.06	3.60	334.33
3:30 PM	20.06	3.55	339.04

Lift	**38.1**	**cm**	$Q_{L,ave}$	**338.84**	**l min^{-1}**
Salinity	**1**	**ppt**	$Q_{G,ave}$	**495.00**	**l min^{-1}**
C_s	**7.91**	**mg l^{-1}**	Q_G:Q_L	**1.46**	
V_{tank}	**7973**	**liters**			

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		C_{out} - C_t	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
2:12:12 PM	27.8	26.9	7.9	7.9	0.0	0.0	0.000
2:13:12 PM	27.8	26.9	7.9	8.0	0.1	0.0	0.049
2:14:12 PM	27.8	26.9	7.9	8.0	0.1	0.0	0.049
2:15:12 PM	27.8	26.9	2.8	6.8	4.0	5.1	1.952
2:16:13 PM	27.8	26.9	0.1	1.5	1.4	7.8	0.683
2:17:12 PM	27.8	26.9	0.2	2.1	1.9	7.7	0.927
2:18:12 PM	27.9	26.9	0.4	1.7	1.3	7.5	0.634
2:19:12 PM	27.8	26.9	0.5	1.5	1.0	7.4	0.488
2:20:12 PM	27.8	26.9	0.6	1.6	1.0	7.3	0.488
2:21:12 PM	27.9	26.9	0.5	1.8	1.3	7.4	0.634
2:22:13 PM	27.9	26.9	0.5	1.9	1.4	7.4	0.683
2:23:12 PM	27.9	27.0	0.5	2.1	1.6	7.4	0.781
2:24:12 PM	27.9	27.0	0.6	2.2	1.6	7.3	0.781
2:25:12 PM	27.9	27.0	0.7	2.5	1.8	7.2	0.878
2:26:12 PM	27.9	27.0	0.9	2.7	1.8	7.0	0.878
2:27:12 PM	28.0	27.0	1.2	2.9	1.7	6.7	0.829
2:28:13 PM	27.9	27.0	1.4	3.2	1.8	6.5	0.878
2:29:12 PM	27.9	27.0	1.6	3.4	1.8	6.3	0.878
2:30:12 PM	28.0	27.0	1.9	3.6	1.7	6.0	0.829

15.2 cm air-lift_Trial 1_7/19/2007 (continued)

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		$C_{out} - C_t$	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
2:31:12 PM	28.0	27.0	2.1	3.8	1.7	5.8	0.829
2:32:14 PM	28.0	27.0	2.4	3.9	1.5	5.5	0.732
2:33:14 PM	28.0	27.0	2.6	4.1	1.5	5.3	0.732
2:34:14 PM	28.0	27.0	2.8	4.2	1.4	5.1	0.683
2:35:14 PM	28.0	27.0	3.0	4.4	1.4	4.9	0.683
2:36:14 PM	28.0	27.0	3.2	4.6	1.4	4.7	0.683
2:37:14 PM	28.0	27.0	3.4	4.7	1.3	4.5	0.634
2:38:14 PM	28.0	27.0	3.6	4.9	1.3	4.3	0.634
2:39:14 PM	28.0	27.0	3.7	5.0	1.3	4.2	0.634
2:40:14 PM	28.0	27.0	4.0	5.1	1.1	3.9	0.537
2:41:14 PM	28.0	27.0	4.2	5.2	1.0	3.7	0.488
2:42:14 PM	28.0	27.0	4.3	5.3	1.0	3.6	0.488
2:43:14 PM	28.0	27.0	4.4	5.4	1.0	3.5	0.488
2:44:14 PM	28.0	27.0	4.6	5.6	1.0	3.3	0.488
2:45:14 PM	28.0	27.0	4.7	5.7	1.0	3.2	0.488
2:46:14 PM	28.0	27.0	4.8	5.7	0.9	3.1	0.439
2:47:14 PM	28.0	27.0	4.9	5.8	0.9	3.0	0.439
2:48:14 PM	28.0	27.0	5.1	5.9	0.8	2.8	0.390
2:49:14 PM	28.0	27.0	5.2	6.0	0.8	2.7	0.390
2:50:14 PM	28.0	27.0	5.3	6.1	0.8	2.6	0.390
2:51:14 PM	28.0	27.0	5.4	6.2	0.8	2.5	0.390
2:52:14 PM	28.0	27.0	5.5	6.3	0.8	2.4	0.390
2:53:14 PM	28.0	27.0	5.6	6.3	0.7	2.3	0.342
2:54:14 PM	28.0	27.0	5.7	6.4	0.7	2.2	0.342
2:55:14 PM	28.0	27.0	5.8	6.4	0.6	2.1	0.293
2:56:14 PM	28.0	27.0	5.9	6.5	0.6	2.0	0.293
2:57:14 PM	28.0	27.0	6.0	6.6	0.6	1.9	0.293
2:58:14 PM	28.0	27.0	6.0	6.6	0.6	1.9	0.293
2:59:14 PM	28.0	27.0	6.1	6.6	0.5	1.8	0.244
3:00:14 PM	28.0	27.0	6.2	6.7	0.5	1.7	0.244
3:01:14 PM	28.0	27.0	6.2	6.8	0.6	1.7	0.293
3:02:15 PM	28.0	27.0	6.3	6.9	0.6	1.6	0.293
3:03:15 PM	28.0	27.0	6.4	6.9	0.5	1.5	0.244
3:04:15 PM	28.0	27.0	6.4	6.9	0.5	1.5	0.244
3:05:15 PM	28.0	27.0	6.5	7.0	0.5	1.4	0.244

15.2 cm air-lift_Trial 1_7/19/2007 (continued)

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		$C_{out} - C_t$	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
3:06:15 PM	28.0	27.0	6.6	7.0	0.4	1.3	0.195
3:07:15 PM	28.0	27.0	6.6	7.0	0.4	1.3	0.195
3:08:15 PM	28.0	27.0	6.7	7.1	0.4	1.2	0.195
3:09:15 PM	28.0	27.0	6.7	7.1	0.4	1.2	0.195
3:10:15 PM	28.0	27.0	6.8	7.2	0.4	1.1	0.195
3:11:15 PM	28.0	27.0	6.8	7.2	0.4	1.1	0.195
3:12:15 PM	28.0	27.0	6.8	7.2	0.4	1.1	0.195
3:13:15 PM	28.0	27.0	6.9	7.2	0.3	1.0	0.146
3:14:15 PM	28.1	27.0	6.9	7.3	0.4	1.0	0.195
3:15:15 PM	28.1	27.0	7.0	7.3	0.3	0.9	0.146
3:16:15 PM	28.1	27.0	7.0	7.3	0.3	0.9	0.146
3:17:15 PM	28.1	27.0	7.0	7.4	0.4	0.9	0.195
3:18:15 PM	28.1	27.0	7.1	7.4	0.3	0.8	0.146
3:19:15 PM	28.1	27.0	7.1	7.4	0.3	0.8	0.146
3:20:15 PM	28.1	27.0	7.1	7.4	0.3	0.8	0.146
3:21:15 PM	28.1	27.0	7.2	7.5	0.3	0.7	0.146
3:22:15 PM	28.1	27.0	7.2	7.5	0.3	0.7	0.146
3:23:15 PM	28.1	27.0	7.2	7.5	0.3	0.7	0.146
3:24:15 PM	28.1	27.0	7.2	7.5	0.3	0.7	0.146
3:25:15 PM	28.1	27.0	7.3	7.5	0.2	0.6	0.098
3:26:15 PM	28.1	27.0	7.3	7.5	0.2	0.6	0.098
3:27:15 PM	28.1	27.0	7.3	7.6	0.3	0.6	0.146
3:28:15 PM	28.1	27.0	7.3	7.6	0.3	0.6	0.146
3:29:15 PM	28.2	27.0	7.3	7.6	0.3	0.6	0.146
3:30:15 PM	28.1	27.0	7.4	7.6	0.2	0.5	0.098
3:31:16 PM	28.1	27.0	7.4	7.6	0.2	0.5	0.098
3:32:17 PM	28.2	27.0	7.4	7.6	0.2	0.5	0.098
3:33:17 PM	28.1	27.0	7.4	7.6	0.2	0.5	0.098
3:34:16 PM	28.1	27.0	7.4	7.7	0.3	0.5	0.146

15.2 cm air-lift_Trial 2_7/20/2007

Hydraulic Summary

Time	Volume [liters]	Fill time [sec]	Q_L [l min^{-1}]
10:45 AM	20.06	3.50	343.89
11:15 AM	20.06	3.68	327.07
11:45 AM	20.06	3.60	334.33

Lift	**38.1**	**cm**	$Q_{L,ave}$	**335.09**	**l min^{-1}**
Salinity	**1**	**ppt**	$Q_{G,ave}$	**495.00**	**l min^{-1}**
C_s	**7.85**	**mg l^{-1}**	Q_G:Q_L	**1.48**	
V_{tank}	**7973**	**liters**			

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		C_{out} - C_t	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
10:59:34 AM	28.8	27.2	7.9	7.8	-0.1	-0.1	-0.048
11:00:04 AM	28.8	27.2	7.9	7.9	0.0	-0.1	0.000
11:00:34 AM	28.8	27.2	7.9	7.8	-0.1	-0.1	-0.048
11:01:04 AM	28.8	27.2	7.9	7.8	-0.1	-0.1	-0.048
11:01:34 AM	28.8	27.2	5.4	5.8	0.4	2.5	0.193
11:02:04 AM	28.8	27.2	0.3	3.6	3.3	7.6	1.592
11:02:34 AM	28.8	27.2	0.2	1.6	1.4	7.7	0.676
11:03:04 AM	28.8	27.2	0.1	1.3	1.2	7.8	0.579
11:03:34 AM	28.8	27.2	0.1	1.3	1.2	7.8	0.579
11:04:04 AM	28.8	27.2	0.1	1.2	1.1	7.8	0.531
11:04:34 AM	28.8	27.2	0.1	1.3	1.2	7.8	0.579
11:05:04 AM	28.7	27.2	0.1	1.1	1.0	7.8	0.483
11:05:34 AM	28.8	27.1	0.1	0.9	0.8	7.8	0.386
11:06:04 AM	28.7	27.2	0.1	0.7	0.6	7.8	0.290
11:06:34 AM	28.8	27.2	0.1	0.6	0.5	7.8	0.241
11:07:04 AM	28.7	27.2	0.1	0.7	0.6	7.8	0.290
11:07:34 AM	28.7	27.2	0.1	0.8	0.7	7.8	0.338
11:08:04 AM	28.8	27.2	0.1	1.0	0.9	7.8	0.434
11:08:34 AM	28.7	27.2	0.1	1.4	1.3	7.8	0.627
11:09:04 AM	28.8	27.2	0.1	1.6	1.5	7.8	0.724
11:09:34 AM	28.7	27.2	0.1	1.7	1.6	7.8	0.772
11:10:04 AM	28.7	27.2	0.2	1.8	1.6	7.7	0.772
11:10:34 AM	28.7	27.2	0.3	1.9	1.6	7.6	0.772

15.2 cm air-lift_Trial 2_7/20/2007 (continued)

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		C_{out} - C_t	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
11:11:04 AM	28.7	27.2	0.4	2.0	1.6	7.5	0.772
11:11:34 AM	28.7	27.2	0.5	2.2	1.7	7.4	0.820
11:12:06 AM	28.7	27.2	0.6	2.3	1.7	7.3	0.820
11:12:36 AM	28.7	27.2	0.7	2.5	1.8	7.2	0.869
11:13:05 AM	28.7	27.2	0.9	2.5	1.6	7.0	0.772
11:13:35 AM	28.7	27.2	1.0	2.7	1.7	6.9	0.820
11:14:05 AM	28.7	27.2	1.1	2.9	1.8	6.8	0.869
11:14:35 AM	28.7	27.2	1.3	2.8	1.5	6.6	0.724
11:15:06 AM	28.7	27.2	1.4	2.9	1.5	6.5	0.724
11:15:35 AM	28.6	27.2	1.5	3.0	1.5	6.4	0.724
11:16:05 AM	28.7	27.2	1.7	3.2	1.5	6.2	0.724
11:16:35 AM	28.6	27.2	1.9	3.3	1.4	6.0	0.676
11:17:05 AM	28.6	27.2	2.0	3.4	1.4	5.9	0.676
11:17:36 AM	28.6	27.2	2.1	3.5	1.4	5.8	0.676
11:18:05 AM	28.6	27.2	2.3	3.6	1.3	5.6	0.627
11:18:36 AM	28.6	27.2	2.4	3.7	1.3	5.5	0.627
11:19:05 AM	28.6	27.2	2.5	3.8	1.3	5.4	0.627
11:19:35 AM	28.6	27.2	2.6	3.9	1.3	5.3	0.627
11:20:05 AM	28.7	27.2	2.7	3.9	1.2	5.2	0.579
11:20:36 AM	28.6	27.2	2.8	4.0	1.2	5.1	0.579
11:21:05 AM	28.6	27.2	3.0	4.1	1.1	4.9	0.531
11:21:35 AM	28.6	27.2	3.1	4.2	1.1	4.8	0.531
11:22:05 AM	28.6	27.2	3.2	4.3	1.1	4.7	0.531
11:22:35 AM	28.6	27.2	3.3	4.4	1.1	4.6	0.531
11:23:05 AM	28.6	27.2	3.4	4.4	1.0	4.5	0.483
11:23:35 AM	28.6	27.2	3.5	4.5	1.0	4.4	0.483
11:24:05 AM	28.6	27.2	3.6	4.6	1.0	4.3	0.483
11:24:35 AM	28.6	27.2	3.7	4.6	0.9	4.2	0.434
11:25:05 AM	28.6	27.2	3.7	4.7	1.0	4.2	0.483
11:25:35 AM	28.6	27.2	3.8	4.7	0.9	4.1	0.434
11:26:05 AM	28.5	27.2	3.9	4.9	1.0	4.0	0.483
11:26:37 AM	28.5	27.2	4.0	4.9	0.9	3.9	0.434
11:27:07 AM	28.5	27.2	4.1	5.0	0.9	3.8	0.434
11:27:37 AM	28.5	27.2	4.2	5.0	0.8	3.7	0.386
11:28:07 AM	28.5	27.2	4.3	5.1	0.8	3.6	0.386

15.2 cm air-lift_Trial 2_7/20/2007 (continued)

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		C_{out} - C_t	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
11:28:37 AM	28.6	27.2	4.3	5.1	0.8	3.6	0.386
11:29:07 AM	28.5	27.2	4.4	5.2	0.8	3.5	0.386
11:29:37 AM	28.5	27.2	4.5	5.3	0.8	3.4	0.386
11:30:07 AM	28.5	27.2	4.6	5.4	0.8	3.3	0.386
11:30:37 AM	28.5	27.2	4.7	5.4	0.7	3.2	0.338
11:31:07 AM	28.5	27.2	4.8	5.5	0.7	3.1	0.338
11:31:37 AM	28.5	27.2	4.8	5.5	0.7	3.1	0.338
11:32:07 AM	28.5	27.2	4.9	5.6	0.7	3.0	0.338
11:32:37 AM	28.5	27.2	4.9	5.6	0.7	3.0	0.338
11:33:07 AM	28.5	27.2	5.0	5.6	0.6	2.9	0.290
11:33:37 AM	28.5	27.2	5.1	5.7	0.6	2.8	0.290
11:34:07 AM	28.5	27.2	5.2	5.7	0.5	2.7	0.241
11:34:37 AM	28.5	27.2	5.2	5.8	0.6	2.7	0.290
11:35:07 AM	28.5	27.2	5.3	5.8	0.5	2.6	0.241
11:35:37 AM	28.5	27.2	5.3	5.8	0.5	2.6	0.241
11:36:07 AM	28.5	27.2	5.4	5.9	0.5	2.5	0.241
11:36:37 AM	28.5	27.2	5.5	5.9	0.4	2.4	0.193
11:37:07 AM	28.5	27.2	5.5	6.0	0.5	2.4	0.241
11:37:37 AM	28.5	27.2	5.6	6.0	0.4	2.3	0.193
11:38:07 AM	28.5	27.2	5.6	6.1	0.5	2.3	0.241
11:38:37 AM	28.4	27.2	5.7	6.1	0.4	2.2	0.193
11:39:07 AM	28.5	27.2	5.7	6.2	0.5	2.2	0.241
11:39:37 AM	28.4	27.2	5.8	6.2	0.4	2.1	0.193
11:40:07 AM	28.4	27.2	5.8	6.2	0.4	2.1	0.193
11:40:38 AM	28.5	27.2	5.9	6.2	0.3	2.0	0.145
11:41:08 AM	28.4	27.2	5.9	6.3	0.4	2.0	0.193
11:41:38 AM	28.4	27.2	6.0	6.3	0.3	1.9	0.145
11:42:08 AM	28.4	27.2	6.0	6.4	0.4	1.9	0.193
11:42:38 AM	28.5	27.2	6.0	6.4	0.4	1.9	0.193
11:43:08 AM	28.4	27.2	6.1	6.4	0.3	1.8	0.145
11:43:38 AM	28.4	27.2	6.1	6.4	0.3	1.8	0.145
11:44:08 AM	28.4	27.2	6.2	6.5	0.3	1.7	0.145
11:44:38 AM	28.4	27.2	6.2	6.5	0.3	1.7	0.145
11:45:08 AM	28.4	27.2	6.2	6.5	0.3	1.7	0.145
11:45:38 AM	28.4	27.2	6.3	6.6	0.3	1.6	0.145

15.2 cm air-lift_Trial 2_7/20/2007 (continued)

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		$C_{out} - C_t$	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
11:46:08 AM	28.4	27.2	6.3	6.6	0.3	1.6	0.145
11:46:38 AM	28.4	27.2	6.4	6.6	0.2	1.5	0.097
11:47:08 AM	28.4	27.2	6.4	6.6	0.2	1.5	0.097
11:47:38 AM	28.4	27.2	6.4	6.7	0.3	1.5	0.145
11:48:08 AM	28.4	27.2	6.5	6.7	0.2	1.4	0.097
11:48:38 AM	28.4	27.2	6.5	6.7	0.2	1.4	0.097
11:49:08 AM	28.4	27.2	6.5	6.7	0.2	1.4	0.097
11:49:38 AM	28.4	27.2	6.6	6.8	0.2	1.3	0.097
11:50:08 AM	28.4	27.2	6.6	6.8	0.2	1.3	0.097
11:50:38 AM	28.4	27.2	6.6	6.8	0.2	1.3	0.097
11:51:08 AM	28.4	27.2	6.6	6.8	0.2	1.3	0.097
11:51:38 AM	28.4	27.2	6.7	6.9	0.2	1.2	0.097
11:52:08 AM	28.4	27.2	6.7	6.9	0.2	1.2	0.097
11:52:38 AM	28.4	27.2	6.7	6.9	0.2	1.2	0.097
11:53:08 AM	28.4	27.2	6.8	6.9	0.1	1.1	0.048
11:53:39 AM	28.4	27.2	6.8	6.9	0.1	1.1	0.048
11:54:10 AM	28.4	27.2	6.8	7.0	0.2	1.1	0.097
11:54:39 AM	28.4	27.2	6.8	7.0	0.2	1.1	0.097
11:55:10 AM	28.4	27.2	6.9	7.0	0.1	0.9	0.048
11:55:39 AM	28.4	27.2	6.9	7.0	0.1	0.9	0.048
11:56:10 AM	28.4	27.2	6.9	7.1	0.2	0.9	0.097
11:56:39 AM	28.4	27.2	6.9	7.1	0.2	0.9	0.097
11:57:10 AM	28.4	27.2	7.0	7.1	0.1	0.9	0.048
11:57:39 AM	28.4	27.2	7.0	7.1	0.1	0.9	0.048
11:58:10 AM	28.4	27.2	7.0	7.1	0.1	0.9	0.048
11:58:39 AM	28.3	27.2	7.0	7.1	0.1	0.9	0.048
11:59:10 AM	28.4	27.2	7.0	7.1	0.1	0.9	0.048
11:59:39 AM	28.4	27.2	7.1	7.2	0.1	0.8	0.048
12:00:10 PM	28.4	27.2	7.1	7.2	0.1	0.8	0.048
12:00:39 PM	28.4	27.2	7.1	7.2	0.1	0.8	0.048
12:01:10 PM	28.4	27.2	7.1	7.2	0.1	0.8	0.048
12:01:39 PM	28.4	27.2	7.1	7.2	0.1	0.8	0.048
12:02:10 PM	28.4	27.2	7.2	7.2	0.0	0.6	0.000

15.2 cm air-lift_Trial 3_7/20/2007

Hydraulic Summary

Time	Volume [liters]	Fill time [sec]	Q_L [l min^{-1}]
3:00 PM	20.06	3.66	328.85
3:30 PM	20.06	3.51	342.91
4:30 PM	20.06	3.60	334.33

Lift	**38.1**	**cm**	$Q_{L,ave}$	**335.36**	**l min^{-1}**
Salinity	**1**	**ppt**	$Q_{G,ave}$	**495.00**	**l min^{-1}**
C_s	**7.83**	**mg l^{-1}**	Q_G:Q_L	**1.48**	
V_{tank}	**7973**	**liters**			

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		C_{out} - C_t	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
3:14:13 PM	28.5	27.3	8.1	8.1	0.0	-0.3	0.000
3:14:43 PM	28.6	27.3	8.0	8.1	0.1	-0.2	0.048
3:15:13 PM	28.6	27.3	8.0	8.1	0.1	-0.2	0.048
3:15:43 PM	28.6	27.3	1.9	8.1	6.2	5.9	2.994
3:16:13 PM	28.6	27.3	0.2	6.3	6.1	7.6	2.946
3:16:43 PM	28.6	27.3	0.1	4.5	4.4	7.7	2.125
3:17:13 PM	28.5	27.3	0.1	3.4	3.3	7.7	1.594
3:17:43 PM	28.6	27.3	0.1	2.6	2.5	7.7	1.207
3:18:13 PM	28.6	27.3	0.1	2.1	2.0	7.7	0.966
3:18:43 PM	28.5	27.3	0.1	1.8	1.7	7.7	0.821
3:19:13 PM	28.5	27.3	0.1	0.1	0.0	7.7	0.000
3:19:43 PM	28.5	27.3	0.1	0.1	0.0	7.7	0.000
3:20:13 PM	28.5	27.3	0.1	0.1	0.0	7.7	0.000
3:20:43 PM	28.6	27.3	0.1	0.1	0.0	7.7	0.000
3:21:13 PM	28.5	27.3	0.1	0.1	0.0	7.7	0.000
3:21:43 PM	28.5	27.3	0.1	1.7	1.6	7.7	0.773
3:22:13 PM	28.5	27.4	0.1	1.8	1.7	7.7	0.821
3:22:43 PM	28.5	27.4	0.1	2.0	1.9	7.7	0.918
3:23:13 PM	28.5	27.4	0.1	2.0	1.9	7.7	0.918
3:23:43 PM	28.5	27.4	0.1	2.1	2.0	7.7	0.966
3:24:13 PM	28.5	27.4	0.1	2.2	2.1	7.7	1.014
3:24:43 PM	28.5	27.4	0.1	2.4	2.3	7.7	1.111
3:25:13 PM	28.5	27.4	0.1	2.4	2.3	7.7	1.111

15.2 cm air-lift_Trial 3_7/20/2007 (continued)

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		$C_{out} - C_t$	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
3:25:43 PM	28.5	27.4	0.2	2.7	2.5	7.6	1.207
3:26:13 PM	28.5	27.4	0.5	2.8	2.3	7.3	1.111
3:26:43 PM	28.5	27.4	0.4	2.8	2.4	7.4	1.159
3:27:13 PM	28.5	27.4	0.6	3.0	2.4	7.2	1.159
3:27:43 PM	28.5	27.4	0.8	3.0	2.2	7.0	1.062
3:28:13 PM	28.5	27.4	1.0	3.1	2.1	6.8	1.014
3:28:43 PM	28.5	27.4	1.2	3.2	2.0	6.6	0.966
3:29:13 PM	28.5	27.4	1.4	3.3	1.9	6.4	0.918
3:29:43 PM	28.5	27.4	1.5	3.3	1.8	6.3	0.869
3:30:13 PM	28.5	27.4	1.7	3.4	1.7	6.1	0.821
3:30:43 PM	28.5	27.4	1.9	3.6	1.7	5.9	0.821
3:31:13 PM	28.5	27.4	2.0	3.7	1.7	5.8	0.821
3:31:43 PM	28.5	27.4	2.1	3.8	1.7	5.7	0.821
3:32:13 PM	28.5	27.4	2.2	3.9	1.7	5.6	0.821
3:32:43 PM	28.6	27.4	2.4	4.0	1.6	5.4	0.773
3:33:13 PM	28.5	27.4	2.5	4.1	1.6	5.3	0.773
3:33:43 PM	28.5	27.4	2.7	4.2	1.5	5.1	0.724
3:34:13 PM	28.6	27.4	2.8	4.2	1.4	5.0	0.676
3:34:43 PM	28.5	27.4	2.9	4.3	1.4	4.9	0.676
3:35:13 PM	28.5	27.4	3.0	4.4	1.4	4.8	0.676
3:35:43 PM	28.5	27.4	3.1	4.5	1.4	4.7	0.676
3:36:13 PM	28.5	27.4	3.2	4.6	1.4	4.6	0.676
3:36:43 PM	28.5	27.4	3.3	4.6	1.3	4.5	0.628
3:37:13 PM	28.5	27.4	3.4	4.7	1.3	4.4	0.628
3:37:43 PM	28.5	27.4	3.5	4.8	1.3	4.3	0.628
3:38:13 PM	28.5	27.4	3.6	4.9	1.3	4.2	0.628
3:38:43 PM	28.5	27.4	3.7	5.0	1.3	4.1	0.628
3:39:13 PM	28.6	27.4	3.8	5.0	1.2	4.0	0.580
3:39:43 PM	28.5	27.4	3.9	5.1	1.2	3.9	0.580
3:40:13 PM	28.5	27.4	4.0	5.2	1.2	3.8	0.580
3:40:43 PM	28.5	27.4	4.1	5.2	1.1	3.7	0.531
3:41:13 PM	28.6	27.4	4.2	5.3	1.1	3.6	0.531
3:41:43 PM	28.5	27.4	4.3	5.4	1.1	3.5	0.531
3:42:13 PM	28.5	27.4	4.3	5.4	1.1	3.5	0.531
3:42:43 PM	28.5	27.4	4.4	5.4	1.0	3.4	0.483

15.2 cm air-lift_Trial 3_7/20/2007 (continued)

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		$C_{out} - C_t$	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
3:43:13 PM	28.5	27.4	4.5	5.5	1.0	3.3	0.483
3:43:43 PM	28.4	27.4	4.6	5.6	1.0	3.2	0.483
3:44:13 PM	28.5	27.4	4.7	5.6	0.9	3.1	0.435
3:44:43 PM	28.5	27.4	4.7	5.7	1.0	3.1	0.483
3:45:13 PM	28.5	27.4	4.8	5.7	0.9	3.0	0.435
3:45:43 PM	28.5	27.4	4.9	5.8	0.9	2.9	0.435
3:46:13 PM	28.5	27.4	4.9	5.8	0.9	2.9	0.435
3:46:43 PM	28.5	27.4	5.0	5.9	0.9	2.8	0.435
3:47:13 PM	28.5	27.4	5.1	5.9	0.8	2.7	0.386
3:47:43 PM	28.5	27.4	5.2	6.0	0.8	2.6	0.386
3:48:13 PM	28.5	27.4	5.2	6.0	0.8	2.6	0.386
3:48:43 PM	28.5	27.4	5.3	6.1	0.8	2.5	0.386
3:49:13 PM	28.5	27.4	5.3	6.1	0.8	2.5	0.386
3:49:43 PM	28.5	27.4	5.4	6.2	0.8	2.4	0.386
3:50:13 PM	28.5	27.4	5.5	6.2	0.7	2.3	0.338
3:50:43 PM	28.5	27.4	5.5	6.3	0.8	2.3	0.386
3:51:13 PM	28.5	27.4	5.6	6.3	0.7	2.2	0.338
3:51:43 PM	28.5	27.4	5.6	6.3	0.7	2.2	0.338
3:52:13 PM	28.5	27.4	5.7	6.4	0.7	2.1	0.338
3:52:43 PM	28.5	27.4	5.7	6.4	0.7	2.1	0.338
3:53:13 PM	28.5	27.4	5.8	6.4	0.6	2.0	0.290
3:53:43 PM	28.4	27.4	5.8	6.5	0.7	2.0	0.338
3:54:13 PM	28.5	27.4	5.9	6.5	0.6	1.9	0.290
3:54:43 PM	28.4	27.4	5.9	6.6	0.7	1.9	0.338
3:55:13 PM	28.4	27.4	6.0	6.6	0.6	1.8	0.290
3:55:43 PM	28.4	27.4	6.0	6.6	0.6	1.8	0.290
3:56:13 PM	28.4	27.4	6.1	6.7	0.6	1.7	0.290
3:56:43 PM	28.4	27.4	6.1	6.7	0.6	1.7	0.290
3:57:13 PM	28.5	27.4	6.1	6.7	0.6	1.7	0.290
3:57:43 PM	28.4	27.4	6.2	6.7	0.5	1.6	0.241
3:58:13 PM	28.5	27.4	6.2	6.8	0.6	1.6	0.290
3:58:43 PM	28.5	27.4	6.3	6.8	0.5	1.5	0.241
3:59:13 PM	28.4	27.4	6.3	6.8	0.5	1.5	0.241
3:59:43 PM	28.4	27.4	6.3	6.9	0.6	1.5	0.290
4:00:13 PM	28.4	27.4	6.4	6.9	0.5	1.4	0.241

15.2 cm air-lift_Trial 3_7/20/2007 (continued)

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		$C_{out} - C_t$	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
4:00:43 PM	28.4	27.4	6.4	6.9	0.5	1.4	0.241
4:01:13 PM	28.4	27.4	6.4	6.9	0.5	1.4	0.241
4:01:43 PM	28.5	27.4	6.5	7.0	0.5	1.3	0.241
4:02:13 PM	28.4	27.4	6.5	7.0	0.5	1.3	0.241
4:02:43 PM	28.4	27.4	6.6	7.0	0.4	1.2	0.193
4:03:13 PM	28.4	27.4	6.6	7.0	0.4	1.2	0.193
4:03:43 PM	28.5	27.4	6.6	7.0	0.4	1.2	0.193
4:04:13 PM	28.4	27.4	6.6	7.0	0.4	1.2	0.193
4:04:43 PM	28.4	27.4	6.7	7.1	0.4	1.1	0.193
4:05:13 PM	28.5	27.4	6.7	7.1	0.4	1.1	0.193
4:05:43 PM	28.5	27.4	6.7	7.1	0.4	1.1	0.193
4:06:13 PM	28.4	27.4	6.8	7.1	0.3	1.0	0.145
4:06:43 PM	28.4	27.4	6.8	7.2	0.4	1.0	0.193
4:07:13 PM	28.5	27.4	6.8	7.2	0.4	1.0	0.193
4:07:43 PM	28.5	27.4	6.8	7.2	0.4	1.0	0.193
4:08:13 PM	28.5	27.4	6.9	7.2	0.3	0.9	0.145
4:08:43 PM	28.4	27.4	6.9	7.2	0.3	0.9	0.145
4:09:13 PM	28.5	27.4	6.9	7.3	0.4	0.9	0.193
4:09:43 PM	28.5	27.4	6.9	7.3	0.4	0.9	0.193
4:10:13 PM	28.5	27.4	7.0	7.3	0.3	0.8	0.145
4:10:43 PM	28.5	27.4	7.0	7.3	0.3	0.8	0.145
4:11:13 PM	28.5	27.4	7.0	7.3	0.3	0.8	0.145
4:11:43 PM	28.5	27.4	7.0	7.3	0.3	0.8	0.145
4:12:13 PM	28.4	27.4	7.1	7.4	0.3	0.7	0.145
4:12:43 PM	28.4	27.4	7.1	7.4	0.3	0.7	0.145
4:13:13 PM	28.5	27.4	7.1	7.4	0.3	0.7	0.145
4:13:43 PM	28.5	27.4	7.1	7.4	0.3	0.7	0.145
4:14:13 PM	28.5	27.4	7.1	7.4	0.3	0.7	0.145
4:14:43 PM	28.5	27.4	7.2	7.4	0.2	0.6	0.097
4:15:13 PM	28.5	27.4	7.2	7.5	0.3	0.6	0.145
4:15:43 PM	28.5	27.4	7.2	7.5	0.3	0.6	0.145
4:16:13 PM	28.5	27.4	7.2	7.5	0.3	0.6	0.145
4:16:43 PM	28.5	27.4	7.2	7.5	0.3	0.6	0.145
4:17:13 PM	28.5	27.4	7.2	7.5	0.3	0.6	0.145
4:17:43 PM	28.5	27.4	7.3	7.5	0.2	0.5	0.097

15.2 cm air-lift_Trial 3_7/20/2007 (continued)

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		C_{out} - C_t	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
4:18:13 PM	28.5	27.4	7.3	7.5	0.2	0.5	0.097
4:18:43 PM	28.5	27.4	7.3	7.5	0.2	0.5	0.097
4:19:13 PM	28.4	27.4	7.3	7.6	0.3	0.5	0.145
4:19:43 PM	28.5	27.4	7.3	7.6	0.3	0.5	0.145
4:20:13 PM	28.5	27.4	7.3	7.6	0.3	0.5	0.145
4:20:43 PM	28.5	27.4	7.4	7.6	0.2	0.4	0.097
4:21:13 PM	28.5	27.4	7.4	7.6	0.2	0.4	0.097
4:21:43 PM	28.5	27.4	7.4	7.6	0.2	0.4	0.097
4:22:13 PM	28.5	27.4	7.4	7.6	0.2	0.4	0.097
4:22:43 PM	28.5	27.4	7.4	7.6	0.2	0.4	0.097
4:23:13 PM	28.5	27.4	7.4	7.6	0.2	0.4	0.097
4:23:43 PM	28.5	27.4	7.5	7.6	0.1	0.3	0.048
4:24:13 PM	28.4	27.4	7.5	7.7	0.2	0.3	0.097
4:24:43 PM	28.4	27.4	7.5	7.7	0.2	0.3	0.097
4:25:13 PM	28.4	27.4	7.5	7.7	0.2	0.3	0.097
4:25:43 PM	28.4	27.4	7.5	7.7	0.2	0.3	0.097
4:26:13 PM	28.5	27.4	7.5	7.7	0.2	0.3	0.097

OTR and $C_{deficit}$ Linear Regression Summary at 495 l min^{-1} air injection

Air-lift [cm]	Trial	Lift [cm]	OTR Coefficient for $C_{deficit}$ equations	R^2
15.2	1	38.1	OTR = 0.1325*$C_{deficit}$	0.984
15.2	2	38.1	OTR = 0.1102*$C_{deficit}$	0.976
15.2	3	38.1	OTR = 0.1386*$C_{deficit}$	0.991

K_La and SOTR Summary for 495 l min^{-1} air injection

		K_La [min^{-1}]		K_La_{20} [min^{-1}]		SOTR [kg hr^{-1}]	
Air-lift [cm]	Trial	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet
15.2	1	0.041	0.043	0.035	0.036	0.1500	0.1573
15.2	2	0.047	0.044	0.039	0.036	0.1696	0.1570
15.2	3	0.049	0.049	0.040	0.041	0.1747	0.1772
	Ave	**0.046**	**0.045**	**0.038**	**0.038**	**0.1648**	**0.1638**
	St. D.	**0.004**	**0.003**	**0.003**	**0.003**	**0.0130**	**0.0116**

AERATION STUDIES (continued)

20.3 cm air-lift_580 l air min^{-1}

20.3 cm air-lift_Trial 1_7/26/2007

Hydraulic Summary

Time	Volume [liters]	Fill time [sec]	Q_L [l min^{-1}]
11:45 AM	20.06	2.55	472.00
12:30 PM	20.06	2.60	462.92
1:00 PM	20.06	2.45	491.27

Lift	**30**	**cm**	$Q_{L,ave}$	**475.40**	**l min^{-1}**
Salinity	**1**	**ppt**	$Q_{G,ave}$	**580.40**	**l min^{-1}**
C_s	**7.99**	**mg l^{-1}**	Q_G:Q_L	**1.22**	
V_{tank}	**8437**	**liters**			

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		C_{out} - C_t	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
11:49:26 AM	27.8	26.3	8.2	8.3	0.1	-0.2	0.068
11:49:56 AM	27.8	26.3	8.2	8.3	0.1	-0.2	0.068
11:50:26 AM	27.8	26.3	8.2	8.3	0.1	-0.2	0.068
11:50:56 AM	27.8	26.3	8.1	6.6	-1.5	-0.1	-1.027
11:51:26 AM	27.8	26.3	2.8	4.0	1.2	5.2	0.821
11:51:57 AM	27.8	26.3	0.2	2.7	2.5	7.8	1.711
11:52:26 AM	27.8	26.3	0.1	1.4	1.3	7.9	0.890
11:52:56 AM	27.8	26.3	0.1	1.3	1.2	7.9	0.821
11:53:26 AM	27.8	26.3	0.1	1.3	1.2	7.9	0.821
11:53:56 AM	27.8	26.3	0.1	1.7	1.6	7.9	1.095
11:54:26 AM	27.8	26.1	0.1	1.3	1.2	7.9	0.821
11:54:56 AM	27.8	26.2	0.1	0.6	0.5	7.9	0.342
11:55:26 AM	27.8	26.3	0.1	0.7	0.6	7.9	0.411
11:55:56 AM	27.8	26.3	0.1	1.4	1.3	7.9	0.890
11:56:27 AM	27.8	26.3	0.1	1.4	1.3	7.9	0.890
11:56:56 AM	27.7	26.3	0.1	1.5	1.4	7.9	0.958
11:57:27 AM	27.7	26.2	0.1	1.3	1.2	7.9	0.821
11:57:56 AM	27.8	26.3	0.1	1.2	1.1	7.9	0.753
11:58:26 AM	27.8	26.3	0.2	1.1	0.9	7.8	0.616
11:58:56 AM	27.8	26.3	0.1	1.2	1.1	7.9	0.753

20.3 cm air-lift_Trial 1_7/26/2007 (continued)

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		$C_{out} - C_t$	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
11:59:26 AM	27.7	26.3	0.3	1.5	1.2	7.7	0.821
11:59:58 AM	27.8	26.3	0.4	1.8	1.4	7.6	0.958
12:00:28 PM	27.7	26.3	0.5	2.0	1.5	7.5	1.027
12:00:58 PM	27.7	26.3	0.6	2.1	1.5	7.4	1.027
12:01:28 PM	27.8	26.3	0.7	2.2	1.5	7.3	1.027
12:01:58 PM	27.7	26.3	0.9	2.4	1.5	7.1	1.027
12:02:28 PM	27.7	26.3	1.1	2.5	1.4	6.9	0.958
12:02:58 PM	27.8	26.3	1.3	2.7	1.4	6.7	0.958
12:03:28 PM	27.7	26.3	1.4	2.8	1.4	6.6	0.958
12:03:58 PM	27.7	26.3	1.5	2.8	1.3	6.5	0.890
12:04:28 PM	27.7	26.3	1.5	3.1	1.6	6.5	1.095
12:04:58 PM	27.7	26.3	1.7	3.2	1.5	6.3	1.027
12:05:28 PM	27.7	26.3	1.9	3.3	1.4	6.1	0.958
12:05:58 PM	27.7	26.3	2.0	3.4	1.4	6.0	0.958
12:06:28 PM	27.7	26.3	2.2	3.5	1.3	5.8	0.890
12:06:58 PM	27.7	26.3	2.3	3.6	1.3	5.7	0.890
12:07:28 PM	27.7	26.3	2.5	3.8	1.3	5.5	0.890
12:07:58 PM	27.7	26.3	2.7	3.9	1.2	5.3	0.821
12:08:28 PM	27.7	26.3	2.8	3.9	1.1	5.2	0.753
12:08:58 PM	27.7	26.3	2.9	4.1	1.2	5.1	0.821
12:09:28 PM	27.7	26.3	3.1	4.2	1.1	4.9	0.753
12:09:58 PM	27.7	26.3	3.2	4.2	1.0	4.8	0.685
12:10:28 PM	27.7	26.3	3.3	4.3	1.0	4.7	0.685
12:10:58 PM	27.7	26.3	3.4	4.4	1.0	4.6	0.685
12:11:28 PM	27.7	26.3	3.5	4.5	1.0	4.5	0.685
12:11:58 PM	27.7	26.3	3.7	4.6	0.9	4.3	0.616
12:12:28 PM	27.7	26.3	3.8	4.7	0.9	4.2	0.616
12:12:58 PM	27.7	26.3	3.8	4.8	1.0	4.2	0.685
12:13:28 PM	27.7	26.3	3.9	4.9	1.0	4.1	0.685
12:13:58 PM	27.7	26.3	4.1	5.0	0.9	3.9	0.616
12:14:28 PM	27.6	26.3	4.2	5.0	0.8	3.8	0.548
12:15:00 PM	27.7	26.3	4.2	5.0	0.8	3.8	0.548
12:15:30 PM	27.7	26.3	4.4	5.2	0.8	3.6	0.548
12:16:00 PM	27.6	26.4	4.5	5.3	0.8	3.5	0.548
12:16:30 PM	27.6	26.3	4.6	5.3	0.7	3.4	0.479

20.3 cm air-lift_Trial 1_7/26/2007 (continued)

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		$C_{out} - C_t$	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
12:17:00 PM	27.6	26.4	4.6	5.4	0.8	3.4	0.548
12:17:29 PM	27.6	26.4	4.7	5.5	0.8	3.3	0.548
12:17:59 PM	27.6	26.3	4.8	5.5	0.7	3.2	0.479
12:18:29 PM	27.6	26.3	4.9	5.5	0.6	3.1	0.411
12:18:59 PM	27.6	26.3	5.0	5.6	0.6	3.0	0.411
12:19:29 PM	27.6	26.4	5.0	5.7	0.7	3.0	0.479
12:19:59 PM	27.6	26.3	5.1	5.8	0.7	2.9	0.479
12:20:29 PM	27.6	26.3	5.2	5.8	0.6	2.8	0.411
12:20:59 PM	27.6	26.3	5.2	5.9	0.7	2.8	0.479
12:21:29 PM	27.6	26.3	5.3	5.9	0.6	2.7	0.411
12:21:59 PM	27.6	26.3	5.4	6.0	0.6	2.6	0.411
12:22:29 PM	27.6	26.3	5.5	6.0	0.5	2.5	0.342
12:22:59 PM	27.6	26.3	5.5	6.1	0.6	2.5	0.411
12:23:29 PM	27.6	26.3	5.6	6.1	0.5	2.4	0.342
12:23:59 PM	27.6	26.4	5.6	6.2	0.6	2.4	0.411
12:24:29 PM	27.6	26.3	5.7	6.2	0.5	2.3	0.342
12:24:59 PM	27.6	26.3	5.7	6.3	0.6	2.3	0.411
12:25:30 PM	27.6	26.3	5.8	6.3	0.5	2.2	0.342
12:25:59 PM	27.6	26.3	5.9	6.4	0.5	2.1	0.342
12:26:30 PM	27.6	26.3	5.9	6.4	0.5	2.1	0.342
12:26:59 PM	27.6	26.3	6.0	6.5	0.5	2.0	0.342
12:27:30 PM	27.6	26.3	6.0	6.5	0.5	2.0	0.342
12:27:59 PM	27.6	26.3	6.1	6.5	0.4	1.9	0.274
12:28:30 PM	27.6	26.4	6.1	6.6	0.5	1.9	0.342
12:29:01 PM	27.6	26.4	6.2	6.6	0.4	1.8	0.274
12:29:31 PM	27.6	26.4	6.2	6.7	0.5	1.8	0.342
12:30:01 PM	27.6	26.4	6.3	6.7	0.4	1.7	0.274
12:30:31 PM	27.6	26.4	6.3	6.7	0.4	1.7	0.274
12:31:01 PM	27.6	26.4	6.4	6.8	0.4	1.6	0.274
12:31:31 PM	27.6	26.4	6.4	6.8	0.4	1.6	0.274
12:32:01 PM	27.6	26.4	6.5	6.8	0.3	1.5	0.205
12:32:31 PM	27.6	26.4	6.5	6.9	0.4	1.5	0.274
12:33:01 PM	27.5	26.4	6.5	6.9	0.4	1.5	0.274
12:33:31 PM	27.5	26.4	6.6	6.9	0.3	1.4	0.205
12:34:01 PM	27.5	26.4	6.6	7.0	0.4	1.4	0.274

20.3 cm air-lift_Trial 1_7/26/2007 (continued)

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		C_{out} - C_t	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
12:34:31 PM	27.5	26.4	6.7	7.0	0.3	1.3	0.205
12:35:01 PM	27.5	26.4	6.7	7.0	0.3	1.3	0.205
12:35:31 PM	27.6	26.4	6.7	7.1	0.4	1.3	0.274
12:36:01 PM	27.5	26.4	6.8	7.1	0.3	1.2	0.205
12:36:31 PM	27.5	26.3	6.8	7.1	0.3	1.2	0.205
12:37:01 PM	27.5	26.4	6.8	7.1	0.3	1.2	0.205
12:37:31 PM	27.5	26.4	6.9	7.2	0.3	1.1	0.205
12:38:01 PM	27.5	26.4	6.9	7.2	0.3	1.1	0.205
12:38:31 PM	27.5	26.4	6.9	7.2	0.3	1.1	0.205
12:39:01 PM	27.5	26.4	7.0	7.2	0.2	1.0	0.137
12:39:31 PM	27.5	26.4	7.0	7.3	0.3	1.0	0.205
12:40:01 PM	27.6	26.4	7.0	7.3	0.3	1.0	0.205
12:40:31 PM	27.5	26.4	7.0	7.3	0.3	1.0	0.205
12:41:01 PM	27.5	26.4	7.1	7.3	0.2	0.9	0.137
12:41:31 PM	27.5	26.4	7.1	7.4	0.3	0.9	0.205
12:42:01 PM	27.5	26.4	7.1	7.4	0.3	0.9	0.205
12:42:32 PM	27.5	26.4	7.2	7.4	0.2	0.8	0.137
12:43:02 PM	27.5	26.4	7.2	7.4	0.2	0.8	0.137
12:43:32 PM	27.5	26.4	7.2	7.4	0.2	0.8	0.137
12:44:02 PM	27.5	26.4	7.2	7.4	0.2	0.8	0.137
12:44:32 PM	27.5	26.4	7.3	7.5	0.2	0.7	0.137
12:45:02 PM	27.5	26.4	7.3	7.5	0.2	0.7	0.137
12:45:32 PM	27.5	26.4	7.3	7.5	0.2	0.7	0.137
12:46:02 PM	27.5	26.4	7.3	7.5	0.2	0.7	0.137
12:46:32 PM	27.5	26.4	7.4	7.5	0.1	0.6	0.068
12:47:02 PM	27.5	26.4	7.4	7.6	0.2	0.6	0.137
12:47:32 PM	27.5	26.4	7.4	7.6	0.2	0.6	0.137
12:48:02 PM	27.5	26.4	7.4	7.6	0.2	0.6	0.137
12:48:32 PM	27.5	26.3	7.4	7.6	0.2	0.6	0.137
12:49:02 PM	27.5	26.4	7.5	7.6	0.1	0.5	0.068
12:49:32 PM	27.5	26.4	7.5	7.6	0.1	0.5	0.068
12:50:02 PM	27.5	26.4	7.5	7.6	0.1	0.5	0.068
12:50:32 PM	27.5	26.4	7.5	7.7	0.2	0.5	0.137
12:51:02 PM	27.5	26.4	7.5	7.7	0.2	0.5	0.137
12:51:32 PM	27.5	26.4	7.5	7.7	0.2	0.5	0.137

20.3 cm air-lift_Trial 1_7/26/2007 (continued)

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		$C_{out} - C_t$	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
12:52:02 PM	27.5	26.4	7.6	7.7	0.1	0.4	0.068
12:52:32 PM	27.5	26.4	7.6	7.7	0.1	0.4	0.068
12:53:02 PM	27.5	26.4	7.6	7.7	0.1	0.4	0.068
12:53:32 PM	27.5	26.4	7.6	7.7	0.1	0.4	0.068
12:54:02 PM	27.5	26.4	7.6	7.7	0.1	0.4	0.068
12:54:32 PM	27.5	26.4	7.6	7.7	0.1	0.4	0.068
12:55:02 PM	27.5	26.4	7.6	7.8	0.2	0.4	0.137
12:55:33 PM	27.5	26.4	7.7	7.8	0.1	0.3	0.068
12:56:04 PM	27.5	26.4	7.7	7.8	0.1	0.3	0.068
12:56:33 PM	27.5	26.4	7.7	7.8	0.1	0.3	0.068
12:57:04 PM	27.5	26.4	7.7	7.8	0.1	0.3	0.068
12:57:33 PM	27.5	26.4	7.7	7.8	0.1	0.3	0.068
12:58:04 PM	27.5	26.4	7.7	7.8	0.1	0.3	0.068
12:58:33 PM	27.5	26.4	7.8	7.8	0.0	0.2	0.000
12:59:04 PM	27.5	26.4	7.8	7.9	0.1	0.2	0.068
12:59:33 PM	27.5	26.4	7.8	7.9	0.1	0.2	0.068
1:00:04 PM	27.5	26.4	7.8	7.9	0.1	0.2	0.068
1:00:33 PM	27.5	26.4	7.8	7.9	0.1	0.2	0.068
1:01:04 PM	27.5	26.4	7.8	7.9	0.1	0.2	0.068
1:01:33 PM	27.4	26.4	7.8	7.9	0.1	0.2	0.068
1:02:04 PM	27.5	26.4	7.8	7.9	0.1	0.2	0.068
1:02:33 PM	27.5	26.4	7.8	7.9	0.1	0.2	0.068

20.3 cm air-lift_Trial 2_7/26/2007

Hydraulic Summary

Time	Volume [liters]	Fill time [sec]	Q_L [l min^{-1}]
1:55 PM	20.06	2.56	470.16
2:30 PM	20.06	2.33	516.57
2:50 PM	20.06	2.37	507.85

Lift	**30**	**cm**	$Q_{L,ave}$	**498.19**	**l min^{-1}**
Salinity	**1**	**ppt**	$Q_{G,ave}$	**580.40**	**l min^{-1}**
C_s	**7.99**	**mg l^{-1}**	Q_G:Q_L	**1.17**	
V_{tank}	**8437**	**liters**			

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		C_{out} - C_t	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
1:55:00 PM	27.6	26.5	8.2	8.2	0.0	-0.2	0.000
1:55:31 PM	27.6	26.5	8.2	8.2	0.0	-0.2	0.000
1:56:00 PM	27.6	26.5	8.2	8.2	0.0	-0.2	0.000
1:56:31 PM	27.6	26.5	8.2	8.2	0.0	-0.2	0.000
1:57:00 PM	27.6	26.5	8.2	8.2	0.0	-0.2	0.000
1:57:31 PM	27.6	26.5	7.2	4.4	-2.8	0.8	-2.009
1:58:00 PM	27.6	26.5	4.5	0.7	-3.8	3.5	-2.726
1:58:31 PM	27.6	26.5	0.2	2.6	2.4	7.8	1.722
1:59:00 PM	27.6	26.5	0.2	5.2	5.0	7.8	3.587
1:59:31 PM	27.6	26.5	0.1	2.2	2.1	7.9	1.507
2:00:00 PM	27.6	26.5	0.1	3.7	3.6	7.9	2.583
2:00:31 PM	27.6	26.5	0.1	3.8	3.7	7.9	2.654
2:01:00 PM	27.6	26.5	0.1	1.9	1.8	7.9	1.291
2:01:31 PM	27.6	26.5	0.1	2.9	2.8	7.9	2.009
2:02:00 PM	27.6	26.5	0.1	1.7	1.6	7.9	1.148
2:02:31 PM	27.6	26.5	0.1	0.5	0.4	7.9	0.287
2:03:00 PM	27.6	26.5	0.1	1.1	1.0	7.9	0.717
2:03:31 PM	27.6	26.5	0.1	0.2	0.1	7.9	0.072
2:04:02 PM	27.6	26.5	0.1	0.1	0.0	7.9	0.000
2:04:32 PM	27.6	26.5	0.1	0.2	0.1	7.9	0.072
2:05:02 PM	27.6	26.5	0.1	0.8	0.7	7.9	0.502
2:05:32 PM	27.6	26.5	0.1	0.8	0.7	7.9	0.502
2:06:02 PM	27.6	26.5	0.1	0.9	0.8	7.9	0.574

20.3 cm air-lift_Trial 2_7/26/2007 (continued)

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		$C_{out} - C_t$	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
2:06:32 PM	27.6	26.5	0.3	1.1	0.8	7.7	0.574
2:07:02 PM	27.6	26.5	0.2	1.1	0.9	7.8	0.646
2:07:32 PM	27.6	26.5	0.4	1.4	1.0	7.6	0.717
2:08:02 PM	27.6	26.5	0.4	1.5	1.1	7.6	0.789
2:08:32 PM	27.5	26.5	0.3	1.6	1.3	7.7	0.933
2:09:02 PM	27.5	26.5	0.2	1.7	1.5	7.8	1.076
2:09:32 PM	27.5	26.5	0.3	1.9	1.6	7.7	1.148
2:10:02 PM	27.5	26.5	0.5	2.0	1.5	7.5	1.076
2:10:32 PM	27.5	26.5	0.5	2.2	1.7	7.5	1.220
2:11:02 PM	27.5	26.5	0.5	2.3	1.8	7.5	1.291
2:11:32 PM	27.5	26.5	0.7	2.5	1.8	7.3	1.291
2:12:02 PM	27.5	26.5	0.8	2.6	1.8	7.2	1.291
2:12:32 PM	27.5	26.5	1.1	2.6	1.5	6.9	1.076
2:13:02 PM	27.5	26.5	1.2	2.7	1.5	6.8	1.076
2:13:34 PM	27.5	26.5	1.4	3.1	1.7	6.6	1.220
2:14:03 PM	27.5	26.5	1.6	3.2	1.6	6.4	1.148
2:14:33 PM	27.5	26.5	1.8	3.3	1.5	6.2	1.076
2:15:03 PM	27.5	26.5	1.9	3.4	1.5	6.1	1.076
2:15:33 PM	27.5	26.5	2.0	3.5	1.5	6.0	1.076
2:16:03 PM	27.5	26.5	2.3	3.7	1.4	5.7	1.004
2:16:33 PM	27.5	26.5	2.5	3.7	1.2	5.5	0.861
2:17:03 PM	27.5	26.5	2.6	3.8	1.2	5.4	0.861
2:17:33 PM	27.5	26.5	2.7	4.0	1.3	5.3	0.933
2:18:03 PM	27.5	26.5	2.9	4.0	1.1	5.1	0.789
2:18:33 PM	27.5	26.5	3.0	4.1	1.1	5.0	0.789
2:19:03 PM	27.4	26.5	3.1	4.2	1.1	4.9	0.789
2:19:33 PM	27.5	26.5	3.2	4.3	1.1	4.8	0.789
2:20:03 PM	27.5	26.5	3.4	4.5	1.1	4.6	0.789
2:20:33 PM	27.5	26.5	3.6	4.5	0.9	4.4	0.646
2:21:03 PM	27.5	26.5	3.7	4.5	0.8	4.3	0.574
2:21:33 PM	27.4	26.5	3.8	4.7	0.9	4.2	0.646
2:22:03 PM	27.4	26.5	3.8	4.7	0.9	4.2	0.646
2:22:33 PM	27.4	26.5	3.9	4.9	1.0	4.1	0.717
2:23:05 PM	27.5	26.5	4.1	5.0	0.9	3.9	0.646
2:23:35 PM	27.4	26.6	4.2	5.0	0.8	3.8	0.574

20.3 cm air-lift_Trial 2_7/26/2007 (continued)

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		$C_{out} - C_t$	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
2:24:05 PM	27.4	26.5	4.3	5.1	0.8	3.7	0.574
2:24:35 PM	27.5	26.5	4.4	5.2	0.8	3.6	0.574
2:25:05 PM	27.5	26.5	4.5	5.2	0.7	3.5	0.502
2:25:35 PM	27.5	26.5	4.5	5.3	0.8	3.5	0.574
2:26:05 PM	27.5	26.6	4.6	5.4	0.8	3.4	0.574
2:26:35 PM	27.5	26.6	4.7	5.4	0.7	3.3	0.502
2:27:05 PM	27.4	26.5	4.8	5.5	0.7	3.2	0.502
2:27:35 PM	27.4	26.5	4.9	5.6	0.7	3.1	0.502
2:28:05 PM	27.4	26.6	4.9	5.6	0.7	3.1	0.502
2:28:35 PM	27.5	26.6	5.0	5.7	0.7	3.0	0.502
2:29:05 PM	27.4	26.5	5.1	5.8	0.7	2.9	0.502
2:29:35 PM	27.4	26.5	5.2	5.8	0.6	2.8	0.430
2:30:05 PM	27.4	26.5	5.2	5.9	0.7	2.8	0.502
2:30:35 PM	27.4	26.5	5.3	5.9	0.6	2.7	0.430
2:31:05 PM	27.4	26.6	5.4	5.9	0.5	2.6	0.359
2:31:35 PM	27.4	26.6	5.4	6.0	0.6	2.6	0.430
2:32:06 PM	27.4	26.6	5.5	6.1	0.6	2.5	0.430
2:32:36 PM	27.4	26.6	5.6	6.2	0.6	2.4	0.430
2:33:06 PM	27.4	26.5	5.7	6.2	0.5	2.3	0.359
2:33:36 PM	27.4	26.6	5.7	6.2	0.5	2.3	0.359
2:34:06 PM	27.5	26.6	5.8	6.3	0.5	2.2	0.359
2:34:36 PM	27.4	26.6	5.8	6.3	0.5	2.2	0.359
2:35:06 PM	27.4	26.6	5.9	6.3	0.4	2.1	0.287
2:35:36 PM	27.4	26.6	5.9	6.4	0.5	2.1	0.359
2:36:06 PM	27.4	26.6	6.0	6.4	0.4	2.0	0.287
2:36:36 PM	27.4	26.6	6.0	6.5	0.5	2.0	0.359
2:37:06 PM	27.4	26.6	6.1	6.5	0.4	1.9	0.287
2:37:36 PM	27.4	26.6	6.1	6.6	0.5	1.9	0.359
2:38:06 PM	27.4	26.6	6.2	6.6	0.4	1.8	0.287
2:38:36 PM	27.4	26.6	6.2	6.6	0.4	1.8	0.287
2:39:06 PM	27.4	26.6	6.3	6.7	0.4	1.7	0.287
2:39:36 PM	27.5	26.6	6.3	6.7	0.4	1.7	0.287
2:40:06 PM	27.4	26.6	6.4	6.7	0.3	1.6	0.215
2:40:37 PM	27.5	26.6	6.4	6.8	0.4	1.6	0.287
2:41:08 PM	27.5	26.6	6.5	6.8	0.3	1.5	0.215

20.3 cm air-lift_Trial 2_7/26/2007 (continued)

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		$C_{out} - C_t$	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
2:41:37 PM	27.5	26.6	6.5	6.9	0.4	1.5	0.287
2:42:08 PM	27.4	26.6	6.6	6.9	0.3	1.4	0.215
2:42:37 PM	27.5	26.6	6.6	6.9	0.3	1.4	0.215
2:43:08 PM	27.4	26.6	6.7	6.9	0.2	1.3	0.143
2:43:37 PM	27.4	26.6	6.7	7.0	0.3	1.3	0.215
2:44:08 PM	27.4	26.6	6.7	7.0	0.3	1.3	0.215
2:44:37 PM	27.4	26.6	6.8	7.0	0.2	1.2	0.143
2:45:08 PM	27.4	26.6	6.8	7.1	0.3	1.2	0.215
2:45:37 PM	27.4	26.6	6.8	7.1	0.3	1.2	0.215
2:46:08 PM	27.4	26.6	6.8	7.1	0.3	1.2	0.215
2:46:37 PM	27.4	26.6	6.9	7.1	0.2	1.1	0.143
2:47:08 PM	27.4	26.6	6.9	7.2	0.3	1.1	0.215
2:47:37 PM	27.4	26.6	6.9	7.2	0.3	1.1	0.215
2:48:08 PM	27.4	26.6	7.0	7.2	0.2	1.0	0.143
2:48:39 PM	27.5	26.6	7.0	7.2	0.2	1.0	0.143
2:49:09 PM	27.4	26.6	7.1	7.2	0.1	0.9	0.072
2:49:39 PM	27.4	26.6	7.1	7.3	0.2	0.9	0.143
2:50:09 PM	27.5	26.6	7.1	7.3	0.2	0.9	0.143
2:50:39 PM	27.4	26.6	7.1	7.3	0.2	0.9	0.143
2:51:09 PM	27.5	26.6	7.1	7.3	0.2	0.9	0.143
2:51:39 PM	27.5	26.6	7.2	7.3	0.1	0.8	0.072
2:52:09 PM	27.4	26.6	7.2	7.4	0.2	0.8	0.143

20.3 cm air-lift_Trial 3_7/27/2007

Hydraulic Summary

Time	Volume [liters]	Fill time [sec]	Q_L [l min^{-1}]
9:50 AM	20.06	2.31	521.04
10:30 AM	20.06	2.46	489.27
11:00 AM	20.06	2.38	505.71

Lift	**30**	**cm**	$Q_{L,ave}$	**505.34**	**l min^{-1}**
Salinity	**1**	**ppt**	$Q_{G,ave}$	**580.40**	**l min^{-1}**
C_s	**7.97**	**mg l^{-1}**	Q_G:Q_L	**1.15**	
V_{tank}	**8437**	**liters**			

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		C_{out} - C_t	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
9:58:18 AM	27.7	26.5	8.2	8.3	0.1	-0.2	0.073
9:58:49 AM	27.8	26.5	8.2	8.2	0.0	-0.2	0.000
9:59:18 AM	27.8	26.5	8.2	8.2	0.0	-0.2	0.000
9:59:48 AM	27.7	26.5	8.2	8.3	0.1	-0.2	0.073
10:00:19 AM	27.8	26.5	8.2	8.2	0.0	-0.2	0.000
10:00:48 AM	27.7	26.5	8.2	8.2	0.0	-0.2	0.000
10:01:18 AM	27.7	26.5	8.1	8.2	0.1	-0.1	0.073
10:01:48 AM	27.7	26.5	0.6	2.3	1.7	7.4	1.237
10:02:18 AM	27.7	26.5	0.2	1.3	1.1	7.8	0.800
10:02:48 AM	27.8	26.5	0.1	2.1	2.0	7.9	1.455
10:03:18 AM	27.7	26.5	0.1	3.3	3.2	7.9	2.329
10:03:49 AM	27.7	26.5	0.1	2.8	2.7	7.9	1.965
10:04:18 AM	27.7	26.5	0.1	1.9	1.8	7.9	1.310
10:04:48 AM	27.7	26.5	0.1	0.9	0.8	7.9	0.582
10:05:18 AM	27.8	26.5	0.1	1.1	1.0	7.9	0.728
10:05:49 AM	27.7	26.5	0.1	2.2	2.1	7.9	1.528
10:06:18 AM	27.7	26.5	0.1	1.3	1.2	7.9	0.873
10:06:48 AM	27.7	26.5	0.1	0.7	0.6	7.9	0.437
10:07:18 AM	27.7	26.6	0.1	1.2	1.1	7.9	0.800
10:07:48 AM	27.7	26.6	0.1	0.8	0.7	7.9	0.509
10:08:18 AM	27.7	26.5	0.1	0.6	0.5	7.9	0.364
10:08:50 AM	27.7	26.6	0.1	0.7	0.6	7.9	0.437
10:09:20 AM	27.7	26.5	0.1	0.4	0.3	7.9	0.218

20.3 cm air-lift_Trial 3_7/27/2007 (continued)

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		$C_{out} - C_t$	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
10:09:50 AM	27.7	26.6	0.1	0.5	0.4	7.9	0.291
10:10:20 AM	27.7	26.6	0.1	0.2	0.1	7.9	0.073
10:10:50 AM	27.7	26.6	0.1	0.5	0.4	7.9	0.291
10:11:20 AM	27.7	26.6	0.1	0.4	0.3	7.9	0.218
10:11:50 AM	27.7	26.6	0.1	0.8	0.7	7.9	0.509
10:12:20 AM	27.7	26.6	0.1	0.8	0.7	7.9	0.509
10:12:50 AM	27.6	26.6	0.1	1.0	0.9	7.9	0.655
10:13:20 AM	27.7	26.6	0.1	1.1	1.0	7.9	0.728
10:13:50 AM	27.6	26.6	0.2	1.1	0.9	7.8	0.655
10:14:20 AM	27.7	26.6	0.3	1.4	1.1	7.7	0.800
10:14:50 AM	27.7	26.6	0.5	1.5	1.0	7.5	0.728
10:15:20 AM	27.7	26.6	0.7	1.8	1.1	7.3	0.800
10:15:50 AM	27.7	26.6	0.8	1.9	1.1	7.2	0.800
10:16:20 AM	27.7	26.6	1.0	2.0	1.0	7.0	0.728
10:16:50 AM	27.6	26.6	1.2	2.1	0.9	6.8	0.655
10:17:20 AM	27.6	26.6	1.4	2.3	0.9	6.6	0.655
10:17:50 AM	27.7	26.6	1.6	2.5	0.9	6.4	0.655
10:18:20 AM	27.7	26.6	1.8	2.6	0.8	6.2	0.582
10:18:50 AM	27.7	26.6	2.0	2.7	0.7	6.0	0.509
10:19:20 AM	27.6	26.6	2.1	2.9	0.8	5.9	0.582
10:19:50 AM	27.6	26.6	2.3	3.0	0.7	5.7	0.509
10:20:20 AM	27.6	26.6	2.4	3.1	0.7	5.6	0.509
10:20:50 AM	27.6	26.6	2.6	3.3	0.7	5.4	0.509
10:21:20 AM	27.6	26.6	2.7	3.4	0.7	5.3	0.509
10:21:50 AM	27.6	26.6	2.8	3.5	0.7	5.2	0.509
10:22:20 AM	27.5	26.6	3.0	3.6	0.6	5.0	0.437
10:22:51 AM	27.6	26.6	3.1	3.7	0.6	4.9	0.437
10:23:21 AM	27.5	26.6	3.1	3.8	0.7	4.9	0.509
10:23:51 AM	27.6	26.6	3.2	3.9	0.7	4.8	0.509
10:24:21 AM	27.6	26.6	3.3	4.0	0.7	4.7	0.509
10:24:51 AM	27.5	26.6	3.5	4.2	0.7	4.5	0.509
10:25:21 AM	27.6	26.6	3.6	4.2	0.6	4.4	0.437
10:25:51 AM	27.6	26.6	3.7	4.2	0.5	4.3	0.364
10:26:21 AM	27.5	26.6	3.9	4.4	0.5	4.1	0.364
10:26:51 AM	27.5	26.6	4.0	4.5	0.5	4.0	0.364

20.3 cm air-lift_Trial 3_7/27/2007 (continued)

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		$C_{out} - C_t$	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
10:27:21 AM	27.5	26.6	4.1	4.6	0.5	3.9	0.364
10:27:51 AM	27.5	26.6	4.1	4.7	0.6	3.9	0.437
10:28:21 AM	27.5	26.6	4.3	4.7	0.4	3.7	0.291
10:28:51 AM	27.5	26.6	4.4	4.8	0.4	3.6	0.291
10:29:21 AM	27.5	26.6	4.5	4.9	0.4	3.5	0.291
10:29:51 AM	27.5	26.6	4.5	5.0	0.5	3.5	0.364
10:30:21 AM	27.5	26.6	4.6	5.1	0.5	3.4	0.364
10:30:51 AM	27.5	26.6	4.8	5.1	0.3	3.2	0.218
10:31:21 AM	27.5	26.6	4.8	5.2	0.4	3.2	0.291
10:31:51 AM	27.5	26.6	4.9	5.3	0.4	3.1	0.291
10:32:21 AM	27.5	26.6	5.0	5.4	0.4	3.0	0.291
10:32:51 AM	27.5	26.6	5.1	5.4	0.3	2.9	0.218
10:33:21 AM	27.5	26.6	5.2	5.5	0.3	2.8	0.218
10:33:51 AM	27.5	26.6	5.2	5.5	0.3	2.8	0.218
10:34:21 AM	27.5	26.6	5.3	5.6	0.3	2.7	0.218
10:34:51 AM	27.5	26.6	5.4	5.7	0.3	2.6	0.218
10:35:21 AM	27.5	26.6	5.4	5.7	0.3	2.6	0.218
10:35:51 AM	27.5	26.6	5.5	5.8	0.3	2.5	0.218
10:36:22 AM	27.5	26.6	5.5	5.8	0.3	2.5	0.218
10:36:52 AM	27.5	26.6	5.6	5.9	0.3	2.4	0.218
10:37:22 AM	27.5	26.6	5.6	6.0	0.4	2.4	0.291
10:37:52 AM	27.5	26.6	5.7	6.0	0.3	2.3	0.218
10:38:22 AM	27.5	26.6	5.8	6.1	0.3	2.2	0.218
10:38:52 AM	27.5	26.6	5.8	6.1	0.3	2.2	0.218
10:39:22 AM	27.5	26.6	5.9	6.1	0.2	2.1	0.146
10:39:52 AM	27.5	26.6	6.0	6.2	0.2	2.0	0.146
10:40:22 AM	27.5	26.6	6.0	6.3	0.3	2.0	0.218
10:40:52 AM	27.5	26.6	6.1	6.3	0.2	1.9	0.146
10:41:22 AM	27.5	26.6	6.1	6.4	0.3	1.9	0.218
10:41:52 AM	27.5	26.6	6.2	6.4	0.2	1.8	0.146
10:42:22 AM	27.5	26.6	6.2	6.4	0.2	1.8	0.146
10:42:52 AM	27.5	26.6	6.3	6.5	0.2	1.7	0.146
10:43:22 AM	27.5	26.6	6.3	6.5	0.2	1.7	0.146
10:43:52 AM	27.5	26.6	6.4	6.6	0.2	1.6	0.146
10:44:22 AM	27.5	26.6	6.4	6.7	0.3	1.6	0.218

20.3 cm air-lift_Trial 3_7/27/2007 (continued)

	Temperature [°C]		Dissolved Oxygen [mg l^{-1}]		$C_{out} - C_t$	$C_{deficit}$	OTR
Time	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg O_2 day^{-1}]
10:44:52 AM	27.5	26.6	6.4	6.6	0.2	1.6	0.146
10:45:22 AM	27.5	26.6	6.4	6.6	0.2	1.6	0.146
10:45:52 AM	27.5	26.6	6.5	6.7	0.2	1.5	0.146
10:46:22 AM	27.5	26.6	6.5	6.7	0.2	1.5	0.146
10:46:52 AM	27.5	26.6	6.6	6.8	0.2	1.4	0.146
10:47:22 AM	27.5	26.6	6.7	6.8	0.1	1.3	0.073
10:47:52 AM	27.5	26.6	6.7	6.8	0.1	1.3	0.073
10:48:22 AM	27.5	26.6	6.7	6.8	0.1	1.3	0.073
10:48:54 AM	27.5	26.6	6.8	6.9	0.1	1.2	0.073
10:49:23 AM	27.5	26.6	6.8	6.9	0.1	1.2	0.073
10:49:54 AM	27.5	26.6	6.9	6.9	0.0	1.1	0.000
10:50:23 AM	27.5	26.6	6.9	7.0	0.1	1.1	0.073
10:50:54 AM	27.5	26.6	6.9	7.0	0.1	1.1	0.073
10:51:23 AM	27.5	26.6	7.0	7.1	0.1	1.0	0.073
10:51:54 AM	27.5	26.6	7.0	7.1	0.1	1.0	0.073
10:52:23 AM	27.5	26.6	7.0	7.1	0.1	1.0	0.073
10:52:54 AM	27.5	26.6	7.0	7.1	0.1	1.0	0.073
10:53:23 AM	27.5	26.6	7.1	7.1	0.0	0.9	0.000
10:53:54 AM	27.5	26.6	7.1	7.2	0.1	0.9	0.073
10:54:23 AM	27.5	26.6	7.1	7.2	0.1	0.9	0.073
10:54:54 AM	27.4	26.6	7.2	7.2	0.0	0.8	0.000
10:55:23 AM	27.5	26.6	7.2	7.3	0.1	0.8	0.073
10:55:54 AM	27.4	26.6	7.2	7.3	0.1	0.8	0.073
10:56:23 AM	27.5	26.6	7.2	7.3	0.1	0.8	0.073
10:56:54 AM	27.5	26.6	7.3	7.3	0.0	0.7	0.000
10:57:23 AM	27.5	26.6	7.3	7.3	0.0	0.7	0.000
10:57:54 AM	27.5	26.6	7.3	7.3	0.0	0.7	0.000
10:58:23 AM	27.5	26.6	7.3	7.4	0.1	0.7	0.073

OTR and $C_{deficit}$ Linear Regression Summary at 580 l min^{-1} air injection

Air-lift [cm]	Trial	Lift [cm]	OTR Coefficient for $C_{deficit}$ equations	R^2
20.3	1	30	OTR = 0.0917*$C_{deficit}$	0.920
20.3	2	30	OTR = 0.1585*$C_{deficit}$	0.974
20.3	3	30	OTR = 0.1447*$C_{deficit}$	0.983

K_La and SOTR Summary for 580 l min^{-1} air injection

		K_La [min^{-1}]		K_La_{20} [min^{-1}]		SOTR [kg hr^{-1}]	
Air-lift [cm]	**Trial**	**Inlet**	**Outlet**	**Inlet**	**Outlet**	**Inlet**	**Outlet**
20.3	1	0.053	0.053	0.045	0.045	0.2059	0.2066
20.3	2	0.054	0.053	0.046	0.045	0.2100	0.2053
20.3	3	0.053	0.054	0.045	0.046	0.2046	0.2112
	Ave	**0.053**	**0.053**	**0.045**	**0.045**	**0.2068**	**0.2077**
	St. D.	**0.001**	**0.001**	**0.001**	**0.001**	**0.0028**	**0.0031**

DEGASSING STUDIES

CARBON DIOXIDE CALCULATIONS

Part 1. The method used for calculating CO_2 concentrations based on pH and alkalinity:

$$CO_2 = \frac{(10^{-pH}) * (Alk) * (44,000)}{(4.3 * 10^{-7}) * (50,000)}$$

Where: Alk is total alkalinity in mg $CaCO_3$ l^{-1}

4.3*10^{-7} is the equilibrium reaction constant

44,000 mg in one mol of CO_2

50,000 mg $CaCO_3$ in one equivalent

pH is measured pH

Part 2. The method used for calculating CO_2 concentrations based on head space partial pressures:

$$DCO_2 = B_{CO_2} * \frac{P^G CO_2}{0.3845} * 1.041$$

Where: BCO2 the Bunsen solubility coefficient value for CO2 based on temperature and salinity

1.041 is a multiplication factor for gas monitor calibration

P^GCO_2 is the partial gas pressure of carbon dioxide determined as

$$P^G CO_2 = BP * \frac{\% CO_2}{100}$$

Where: BP is barometric pressure in mm Hg

% CO_2 is the reading taken from the dissolved gas analyzer

DEGASSING STUDIES_pH/Alkalinity Method

10.2 cm air-lift_170 l air min^{-1}

10.2 cm air-lift_Trial 1_8/22/2008

Hydraulic and Alkalinity Summary

Time	Volume [liters]	Fill time [sec]	Q_L [l min^{-1}]	Alk [mg l^{-1}]
9:55 AM	20.06	7.53	159.84	158
10:10 AM	20.06	--	--	154
10:25 AM	20.06	--	--	158
10:45 AM	20.06	7.46	161.34	157
11:05 AM	20.06	--	--	153
11:25 AM	20.06	7.43	161.99	155
11:40 AM	20.06	7.44	161.77	154

Lift	30.5	cm	$Q_{L,ave}$	161.24	l min^{-1}
C_s	0.5	mg l^{-1}	$Q_{G,ave}$	170.00	l min^{-1}
FW_{CO2}	44.01	g mol^{-1}	Q_G:Q_L	1.05	
V_{tank}	7231.6	liters	Alkalinity	156	mg $CaCO_3$ l^{-1}

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		C_t - C_{out}	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
9:48:24 AM	26.1	26.1	8.28	8.32	1.67	1.52	0.15	1.17	0.034
9:49:24 AM	26.1	26.1	8.28	8.32	1.67	1.52	0.15	1.17	0.034
9:50:24 AM	26.1	26.1	8.28	8.32	1.67	1.52	0.15	1.17	0.034
9:51:24 AM	26.1	26.1	8.29	8.32	1.63	1.52	0.11	1.13	0.025
9:52:24 AM	26.1	26.1	7.65	7.43	7.13	11.83	-4.70	6.63	-1.091
9:53:24 AM	26.1	26.1	7.07	7.00	27.10	31.83	-4.74	26.60	-1.100
9:54:24 AM	26.1	26.1	6.84	6.74	46.02	57.93	-11.91	45.52	-2.766
9:55:24 AM	26.2	26.1	6.57	6.50	85.68	100.67	-14.99	85.18	-3.479
9:56:24 AM	26.2	26.1	6.49	6.51	103.01	98.38	4.64	102.51	1.076
9:57:24 AM	26.2	26.1	6.47	6.52	107.87	96.14	11.73	107.37	2.724
9:58:24 AM	26.2	26.1	6.47	6.52	107.87	96.14	11.73	107.37	2.724
9:59:24 AM	26.2	26.1	6.46	6.52	110.38	96.14	14.24	109.88	3.307

10.2 cm air-lift_Trial 1_8/22/2008 (continued)

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		$C_t - C_{out}$	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
10:00:24 AM	26.2	26.1	6.47	6.53	107.87	93.95	13.92	107.37	3.232
10:01:24 AM	26.2	26.1	6.47	6.54	107.87	91.81	16.06	107.37	3.728
10:02:24 AM	26.2	26.1	6.48	6.54	105.41	91.81	13.60	104.91	3.158
10:03:24 AM	26.2	26.1	6.48	6.54	105.41	91.81	13.60	104.91	3.158
10:04:24 AM	26.2	26.1	6.49	6.54	103.01	91.81	11.20	102.51	2.601
10:05:24 AM	26.2	26.1	6.49	6.55	103.01	89.72	13.29	102.51	3.086
10:06:24 AM	26.2	26.1	6.50	6.55	100.67	89.72	10.95	100.17	2.542
10:07:24 AM	26.2	26.1	6.50	6.55	100.67	89.72	10.95	100.17	2.542
10:08:24 AM	26.2	26.1	6.50	6.56	100.67	87.68	12.99	100.17	3.016
10:09:24 AM	26.2	26.1	6.50	6.56	100.67	87.68	12.99	100.17	3.016
10:10:24 AM	26.2	26.1	6.51	6.56	98.38	87.68	10.70	97.88	2.484
10:11:24 AM	26.2	26.1	6.51	6.56	98.38	87.68	10.70	97.88	2.484
10:12:24 AM	26.2	26.1	6.51	6.57	98.38	85.68	12.69	97.88	2.947
10:13:24 AM	26.2	26.1	6.52	6.58	96.14	83.73	12.41	95.64	2.880
10:14:24 AM	26.2	26.1	6.52	6.59	96.14	81.83	14.31	95.64	3.323
10:15:24 AM	26.2	26.1	6.52	6.59	96.14	81.83	14.31	95.64	3.323
10:16:24 AM	26.2	26.1	6.53	6.59	93.95	81.83	12.12	93.45	2.815
10:17:24 AM	26.2	26.1	6.53	6.59	93.95	81.83	12.12	93.45	2.815
10:18:24 AM	26.2	26.1	6.53	6.60	93.95	79.96	13.99	93.45	3.247
10:19:24 AM	26.2	26.1	6.54	6.60	91.81	79.96	11.85	91.31	2.751
10:20:24 AM	26.2	26.1	6.54	6.61	91.81	78.14	13.67	91.31	3.173
10:21:24 AM	26.2	26.1	6.54	6.61	91.81	78.14	13.67	91.31	3.173
10:22:24 AM	26.2	26.1	6.55	6.61	89.72	78.14	11.58	89.22	2.688
10:23:24 AM	26.2	26.1	6.55	6.62	89.72	76.37	13.36	89.22	3.101
10:24:24 AM	26.2	26.1	6.55	6.62	89.72	76.37	13.36	89.22	3.101
10:25:24 AM	26.2	26.1	6.56	6.63	87.68	74.63	13.05	87.18	3.030
10:26:24 AM	26.2	26.1	6.56	6.64	87.68	72.93	14.75	87.18	3.425
10:27:24 AM	26.2	26.1	6.56	6.64	87.68	72.93	14.75	87.18	3.425
10:28:24 AM	26.2	26.1	6.57	6.63	85.68	74.63	11.06	85.18	2.567
10:29:24 AM	26.2	26.1	6.57	6.64	85.68	72.93	12.76	85.18	2.961
10:30:24 AM	26.2	26.1	6.58	6.64	83.73	72.93	10.80	83.23	2.509
10:31:24 AM	26.2	26.1	6.58	6.65	83.73	71.27	12.46	83.23	2.894
10:32:24 AM	26.2	26.1	6.58	6.66	83.73	69.65	14.09	83.23	3.271
10:33:24 AM	26.2	26.1	6.59	6.67	81.83	68.06	13.77	81.33	3.196
10:34:24 AM	26.2	26.1	6.59	6.67	81.83	68.06	13.77	81.33	3.196

10.2 cm air-lift_Trial 1_8/22/2008 (continued)

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		$C_t - C_{out}$	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
10:35:24 AM	26.2	26.1	6.59	6.67	81.83	68.06	13.77	81.33	3.196
10:36:24 AM	26.2	26.1	6.60	6.67	79.96	68.06	11.90	79.46	2.764
10:37:24 AM	26.2	26.1	6.60	6.66	79.96	69.65	10.32	79.46	2.396
10:38:24 AM	26.2	26.1	6.61	6.67	78.14	68.06	10.08	77.64	2.341
10:39:24 AM	26.2	26.1	6.61	6.68	78.14	66.51	11.63	77.64	2.701
10:40:24 AM	26.2	26.1	6.62	6.68	76.37	66.51	9.85	75.87	2.288
10:41:24 AM	26.2	26.1	6.62	6.69	76.37	65.00	11.37	75.87	2.639
10:42:24 AM	26.2	26.1	6.63	6.69	74.63	65.00	9.63	74.13	2.236
10:43:24 AM	26.2	26.1	6.63	6.70	74.63	63.52	11.11	74.13	2.579
10:44:24 AM	26.2	26.1	6.63	6.69	74.63	65.00	9.63	74.13	2.236
10:45:24 AM	26.2	26.1	6.64	6.70	72.93	63.52	9.41	72.43	2.185
10:46:24 AM	26.2	26.1	6.64	6.70	72.93	63.52	9.41	72.43	2.185
10:47:24 AM	26.2	26.1	6.64	6.73	72.93	59.28	13.65	72.43	3.169
10:48:24 AM	26.2	26.1	6.65	6.73	71.27	59.28	11.99	70.77	2.784
10:49:24 AM	26.2	26.1	6.65	6.73	71.27	59.28	11.99	70.77	2.784
10:50:24 AM	26.2	26.1	6.65	6.73	71.27	59.28	11.99	70.77	2.784
10:51:24 AM	26.2	26.1	6.66	6.74	69.65	57.93	11.72	69.15	2.720
10:52:24 AM	26.2	26.1	6.66	6.74	69.65	57.93	11.72	69.15	2.720
10:53:24 AM	26.2	26.1	6.66	6.74	69.65	57.93	11.72	69.15	2.720
10:54:24 AM	26.2	26.1	6.67	6.75	68.06	56.61	11.45	67.56	2.659
10:55:24 AM	26.2	26.1	6.68	6.75	66.51	56.61	9.90	66.01	2.299
10:56:24 AM	26.2	26.1	6.67	6.76	68.06	55.32	12.74	67.56	2.958
10:57:24 AM	26.2	26.1	6.68	6.76	66.51	55.32	11.19	66.01	2.598
10:58:24 AM	26.2	26.1	6.68	6.77	66.51	54.06	12.45	66.01	2.890
10:59:24 AM	26.2	26.1	6.69	6.77	65.00	54.06	10.94	64.50	2.539
11:00:24 AM	26.2	26.1	6.69	6.77	65.00	54.06	10.94	64.50	2.539
11:01:24 AM	26.2	26.1	6.70	6.77	63.52	54.06	9.46	63.02	2.195
11:02:24 AM	26.2	26.1	6.70	6.78	63.52	52.83	10.69	63.02	2.481
11:03:24 AM	26.2	26.1	6.70	6.78	63.52	52.83	10.69	63.02	2.481
11:04:24 AM	26.2	26.1	6.71	6.78	62.07	52.83	9.24	61.57	2.145
11:05:24 AM	26.2	26.1	6.71	6.77	62.07	54.06	8.01	61.57	1.860
11:06:24 AM	26.2	26.1	6.72	6.79	60.66	51.63	9.03	60.16	2.097
11:07:24 AM	26.2	26.1	6.72	6.80	60.66	50.45	10.21	60.16	2.369
11:08:24 AM	26.2	26.1	6.72	6.80	60.66	50.45	10.21	60.16	2.369
11:09:24 AM	26.2	26.1	6.72	6.81	60.66	49.31	11.35	60.16	2.636

10.2 cm air-lift_Trial 1_8/22/2008 (continued)

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		$C_t - C_{out}$	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
11:10:24 AM	26.2	26.1	6.73	6.81	59.28	49.31	9.97	58.78	2.316
11:11:24 AM	26.2	26.1	6.73	6.81	59.28	49.31	9.97	58.78	2.316
11:12:24 AM	26.2	26.1	6.74	6.81	57.93	49.31	8.62	57.43	2.002
11:13:24 AM	26.2	26.1	6.74	6.82	57.93	48.18	9.75	57.43	2.263
11:14:24 AM	26.2	26.1	6.74	6.82	57.93	48.18	9.75	57.43	2.263
11:15:24 AM	26.2	26.1	6.75	6.83	56.61	47.09	9.52	56.11	2.211
11:16:24 AM	26.2	26.1	6.75	6.83	56.61	47.09	9.52	56.11	2.211
11:17:24 AM	26.2	26.1	6.76	6.83	55.32	47.09	8.24	54.82	1.912
11:18:24 AM	26.2	26.1	6.76	6.84	55.32	46.02	9.31	54.82	2.161
11:19:24 AM	26.2	26.1	6.76	6.84	55.32	46.02	9.31	54.82	2.161
11:20:24 AM	26.2	26.2	6.77	6.84	54.06	46.02	8.05	53.56	1.869
11:21:24 AM	26.2	26.2	6.77	6.85	54.06	44.97	9.10	53.56	2.112
11:22:24 AM	26.2	26.2	6.77	6.85	54.06	44.97	9.10	53.56	2.112
11:23:24 AM	26.2	26.2	6.78	6.85	52.83	44.97	7.86	52.33	1.826
11:24:24 AM	26.2	26.2	6.79	6.86	51.63	43.94	7.69	51.13	1.784
11:25:24 AM	26.2	26.2	6.78	6.86	52.83	43.94	8.89	52.33	2.064
11:26:24 AM	26.2	26.2	6.79	6.87	51.63	42.94	8.69	51.13	2.017
11:27:24 AM	26.2	26.2	6.79	6.87	51.63	42.94	8.69	51.13	2.017
11:28:24 AM	26.2	26.2	6.80	6.87	50.45	42.94	7.51	49.95	1.744
11:29:24 AM	26.2	26.2	6.81	6.88	49.31	41.97	7.34	48.81	1.704
11:30:24 AM	26.2	26.2	6.80	6.89	50.45	41.01	9.44	49.95	2.193
11:31:24 AM	26.2	26.2	6.81	6.89	49.31	41.01	8.30	48.81	1.926
11:32:24 AM	26.2	26.2	6.81	6.89	49.31	41.01	8.30	48.81	1.926
11:33:24 AM	26.2	26.2	6.81	6.89	49.31	41.01	8.30	48.81	1.926
11:34:24 AM	26.2	26.2	6.82	6.90	48.18	40.08	8.11	47.68	1.882
11:35:24 AM	26.2	26.2	6.82	6.91	48.18	39.17	9.02	47.68	2.094
11:36:24 AM	26.2	26.2	6.82	6.91	48.18	39.17	9.02	47.68	2.094
11:37:24 AM	26.2	26.2	6.83	6.91	47.09	39.17	7.92	46.59	1.839
11:38:24 AM	26.2	26.2	6.83	6.92	47.09	38.27	8.81	46.59	2.046
11:39:24 AM	26.2	26.2	6.84	6.92	46.02	38.27	7.74	45.52	1.797
11:40:24 AM	26.2	26.2	6.84	6.93	46.02	37.40	8.61	45.52	2.000
11:41:24 AM	26.2	26.2	6.84	6.92	46.02	38.27	7.74	45.52	1.797
11:42:24 AM	26.2	26.2	6.85	6.93	44.97	37.40	7.57	44.47	1.756
11:43:24 AM	26.2	26.2	6.85	6.92	44.97	38.27	6.69	44.47	1.554
11:44:24 AM	26.2	26.2	6.85	6.94	44.97	36.55	8.42	44.47	1.954

10.2 cm air-lift_Trial 1_8/22/2008 (continued)

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		$C_t - C_{out}$	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
11:45:24 AM	26.2	26.2	6.85	6.93	44.97	37.40	7.57	44.47	1.756
11:46:24 AM	26.2	26.2	6.86	6.94	43.94	36.55	7.39	43.44	1.717
11:47:24 AM	26.2	26.2	6.87	6.94	42.94	36.55	6.39	42.44	1.484
11:48:24 AM	26.2	26.2	6.87	6.95	42.94	35.72	7.22	42.44	1.677
11:49:24 AM	26.2	26.2	6.87	6.95	42.94	35.72	7.22	42.44	1.677
11:50:24 AM	26.2	26.2	6.87	6.96	42.94	34.91	8.04	42.44	1.866
11:51:24 AM	26.2	26.2	6.88	6.96	41.97	34.91	7.06	41.47	1.639
11:52:24 AM	26.2	26.2	6.88	6.97	41.97	34.11	7.85	41.47	1.824
11:53:24 AM	26.2	26.2	6.89	6.97	41.01	34.11	6.90	40.51	1.602
11:54:24 AM	26.2	26.2	6.89	6.97	41.01	34.11	6.90	40.51	1.602
11:55:24 AM	26.2	26.2	6.89	6.97	41.01	34.11	6.90	40.51	1.602
11:56:24 AM	26.2	26.2	6.90	6.98	40.08	33.33	6.74	39.58	1.565
11:57:24 AM	26.2	26.2	6.90	6.98	40.08	33.33	6.74	39.58	1.565
11:58:24 AM	26.2	26.2	6.91	6.98	39.17	33.33	5.83	38.67	1.354
11:59:24 AM	26.2	26.2	6.91	6.98	39.17	33.33	5.83	38.67	1.354
12:00:24 PM	26.2	26.2	6.91	7.00	39.17	31.83	7.33	38.67	1.702
12:01:24 PM	26.2	26.2	6.92	7.00	38.27	31.83	6.44	37.77	1.495
12:02:24 PM	26.2	26.2	6.92	7.00	38.27	31.83	6.44	37.77	1.495
12:03:24 PM	26.2	26.2	6.93	7.00	37.40	31.83	5.57	36.90	1.293
12:04:24 PM	26.2	26.2	6.93	7.01	37.40	31.11	6.29	36.90	1.461
12:05:24 PM	26.2	26.2	6.93	7.00	37.40	31.83	5.57	36.90	1.293
12:06:24 PM	26.2	26.2	6.93	7.01	37.40	31.11	6.29	36.90	1.461
12:07:24 PM	26.2	26.2	6.94	7.02	36.55	30.40	6.15	36.05	1.428
12:08:24 PM	26.2	26.2	6.94	7.02	36.55	30.40	6.15	36.05	1.428
12:09:24 PM	26.2	26.2	6.94	7.03	36.55	29.71	6.84	36.05	1.588
12:10:24 PM	26.2	26.2	6.95	7.03	35.72	29.71	6.01	35.22	1.395
12:11:24 PM	26.2	26.2	6.95	7.03	35.72	29.71	6.01	35.22	1.395
12:12:24 PM	26.2	26.2	6.95	7.04	35.72	29.03	6.69	35.22	1.552
12:13:24 PM	26.2	26.2	6.96	7.04	34.91	29.03	5.87	34.41	1.363
12:14:24 PM	26.2	26.2	6.96	7.04	34.91	29.03	5.87	34.41	1.363
12:15:24 PM	26.2	26.2	6.97	7.05	34.11	28.37	5.74	33.61	1.332
12:16:24 PM	26.2	26.2	6.97	7.05	34.11	28.37	5.74	33.61	1.332
12:17:24 PM	26.2	26.2	6.98	7.06	33.33	27.73	5.61	32.83	1.302
12:18:24 PM	26.2	26.2	6.98	7.06	33.33	27.73	5.61	32.83	1.302
12:19:24 PM	26.2	26.2	6.98	7.06	33.33	27.73	5.61	32.83	1.302

10.2 cm air-lift_Trial 1_8/22/2008 (continued)

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		$C_t - C_{out}$	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
12:20:24 PM	26.2	26.2	6.98	7.06	33.33	27.73	5.61	32.83	1.302
12:21:24 PM	26.2	26.2	6.99	7.07	32.58	27.10	5.48	32.08	1.272
12:22:24 PM	26.2	26.2	7.00	7.07	31.83	27.10	4.74	31.33	1.100
12:23:24 PM	26.2	26.2	7.00	7.08	31.83	26.48	5.36	31.33	1.244
12:24:24 PM	26.2	26.2	7.00	7.08	31.83	26.48	5.36	31.33	1.244
12:25:24 PM	26.2	26.2	7.00	7.09	31.83	25.88	5.96	31.33	1.383
12:26:24 PM	26.2	26.2	7.01	7.09	31.11	25.88	5.23	30.61	1.215
12:27:24 PM	26.2	26.2	7.01	7.09	31.11	25.88	5.23	30.61	1.215
12:28:24 PM	26.2	26.2	7.01	7.09	31.11	25.88	5.23	30.61	1.215
12:29:24 PM	26.2	26.2	7.02	7.10	30.40	25.29	5.11	29.90	1.188
12:30:24 PM	26.2	26.2	7.02	7.10	30.40	25.29	5.11	29.90	1.188
12:31:24 PM	26.2	26.2	7.03	7.10	29.71	25.29	4.42	29.21	1.027
12:32:24 PM	26.2	26.2	7.03	7.11	29.71	24.71	5.00	29.21	1.161
12:33:24 PM	26.2	26.2	7.03	7.11	29.71	24.71	5.00	29.21	1.161
12:34:24 PM	26.2	26.2	7.04	7.11	29.03	24.71	4.32	28.53	1.003
12:35:24 PM	26.2	26.2	7.04	7.12	29.03	24.15	4.88	28.53	1.134
12:36:24 PM	26.3	26.2	7.04	7.12	29.03	24.15	4.88	28.53	1.134
12:37:24 PM	26.3	26.2	7.04	7.13	29.03	23.60	5.43	28.53	1.262
12:38:24 PM	26.3	26.2	7.05	7.13	28.37	23.60	4.77	27.87	1.108
12:39:24 PM	26.3	26.2	7.05	7.14	28.37	23.06	5.31	27.87	1.233
12:40:24 PM	26.3	26.2	7.06	7.13	27.73	23.60	4.13	27.23	0.958
12:41:24 PM	26.3	26.2	7.06	7.15	27.73	22.54	5.19	27.23	1.205
12:42:24 PM	26.3	26.2	7.06	7.15	27.73	22.54	5.19	27.23	1.205
12:43:24 PM	26.3	26.2	7.07	7.15	27.10	22.54	4.56	26.60	1.058
12:44:24 PM	26.3	26.2	7.07	7.16	27.10	22.02	5.07	26.60	1.178
12:45:24 PM	26.3	26.2	7.07	7.15	27.10	22.54	4.56	26.60	1.058
12:46:24 PM	26.3	26.2	7.08	7.16	26.48	22.02	4.45	25.98	1.034
12:47:24 PM	26.3	26.2	7.08	7.17	26.48	21.52	4.96	25.98	1.151
12:48:24 PM	26.3	26.2	7.09	7.17	25.88	21.52	4.35	25.38	1.011
12:49:24 PM	26.3	26.2	7.09	7.17	25.88	21.52	4.35	25.38	1.011
12:50:24 PM	26.3	26.2	7.09	7.17	25.88	21.52	4.35	25.38	1.011
12:51:24 PM	26.3	26.2	7.09	7.18	25.88	21.03	4.84	25.38	1.125
12:52:24 PM	26.3	26.2	7.09	7.18	25.88	21.03	4.84	25.38	1.125
12:53:24 PM	26.3	26.2	7.10	7.18	25.29	21.03	4.25	24.79	0.988
12:54:24 PM	26.3	26.2	7.10	7.19	25.29	20.55	4.73	24.79	1.099

10.2 cm air-lift_Trial 1_8/22/2008 (continued)

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		$C_t - C_{out}$	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
12:55:24 PM	26.3	26.2	7.11	7.19	24.71	20.55	4.16	24.21	0.965
12:56:24 PM	26.3	26.2	7.11	7.20	24.71	20.09	4.63	24.21	1.074
12:57:24 PM	26.3	26.2	7.12	7.20	24.15	20.09	4.06	23.65	0.943
12:58:24 PM	26.3	26.2	7.12	7.20	24.15	20.09	4.06	23.65	0.943
12:59:24 PM	26.3	26.2	7.12	7.21	24.15	19.63	4.52	23.65	1.049
1:00:24 PM	26.3	26.2	7.13	7.21	23.60	19.63	3.97	23.10	0.922
1:01:24 PM	26.3	26.2	7.13	7.22	23.60	19.18	4.42	23.10	1.026
1:02:24 PM	26.3	26.2	7.13	7.22	23.60	19.18	4.42	23.10	1.026
1:03:24 PM	26.3	26.2	7.14	7.22	23.06	19.18	3.88	22.56	0.901
1:04:24 PM	26.3	26.2	7.14	7.23	23.06	18.75	4.32	22.56	1.002
1:05:24 PM	26.3	26.2	7.15	7.23	22.54	18.75	3.79	22.04	0.880
1:06:24 PM	26.3	26.2	7.14	7.24	23.06	18.32	4.74	22.56	1.101
1:07:24 PM	26.3	26.2	7.15	7.23	22.54	18.75	3.79	22.04	0.880
1:08:24 PM	26.3	26.2	7.15	7.24	22.54	18.32	4.22	22.04	0.979
1:09:24 PM	26.3	26.2	7.16	7.24	22.02	18.32	3.71	21.52	0.860
1:10:24 PM	26.3	26.2	7.17	7.25	21.52	17.90	3.62	21.02	0.841
1:11:24 PM	26.3	26.2	7.17	7.25	21.52	17.90	3.62	21.02	0.841
1:12:24 PM	26.3	26.2	7.17	7.25	21.52	17.90	3.62	21.02	0.841
1:13:24 PM	26.3	26.2	7.17	7.26	21.52	17.49	4.03	21.02	0.935
1:14:24 PM	26.3	26.2	7.18	7.26	21.03	17.49	3.54	20.53	0.822
1:15:24 PM	26.3	26.2	7.18	7.27	21.03	17.10	3.94	20.53	0.914
1:16:24 PM	26.3	26.2	7.19	7.27	20.55	17.10	3.46	20.05	0.803
1:17:24 PM	26.3	26.2	7.18	7.27	21.03	17.10	3.94	20.53	0.914
1:18:24 PM	26.3	26.2	7.19	7.27	20.55	17.10	3.46	20.05	0.803
1:19:24 PM	26.3	26.2	7.20	7.28	20.09	16.71	3.38	19.59	0.785
1:20:24 PM	26.3	26.2	7.20	7.28	20.09	16.71	3.38	19.59	0.785
1:21:24 PM	26.3	26.2	7.20	7.29	20.09	16.33	3.76	19.59	0.873
1:22:24 PM	26.3	26.2	7.20	7.29	20.09	16.33	3.76	19.59	0.873
1:23:24 PM	26.3	26.2	7.20	7.29	20.09	16.33	3.76	19.59	0.873
1:24:24 PM	26.3	26.2	7.21	7.29	19.63	16.33	3.30	19.13	0.767
1:25:24 PM	26.3	26.2	7.21	7.30	19.63	15.96	3.67	19.13	0.853
1:26:24 PM	26.3	26.2	7.22	7.30	19.18	15.96	3.23	18.68	0.749
1:27:24 PM	26.3	26.2	7.22	7.31	19.18	15.59	3.59	18.68	0.834
1:28:24 PM	26.3	26.2	7.22	7.30	19.18	15.96	3.23	18.68	0.749
1:29:24 PM	26.3	26.2	7.23	7.31	18.75	15.59	3.15	18.25	0.732

10.2 cm air-lift_Trial 1_8/22/2008 (continued)

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		$C_t - C_{out}$	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
1:30:24 PM	26.3	26.2	7.23	7.32	18.75	15.24	3.51	18.25	0.815
1:31:24 PM	26.3	26.2	7.23	7.32	18.75	15.24	3.51	18.25	0.815
1:32:24 PM	26.3	26.2	7.24	7.32	18.32	15.24	3.08	17.82	0.716
1:33:24 PM	26.3	26.2	7.24	7.32	18.32	15.24	3.08	17.82	0.716
1:34:24 PM	26.3	26.2	7.24	7.33	18.32	14.89	3.43	17.82	0.796
1:35:24 PM	26.3	26.2	7.25	7.33	17.90	14.89	3.01	17.40	0.699
1:36:24 PM	26.3	26.2	7.25	7.34	17.90	14.55	3.35	17.40	0.778
1:37:24 PM	26.3	26.2	7.26	7.35	17.49	14.22	3.27	16.99	0.760
1:38:24 PM	26.3	26.3	7.26	7.35	17.49	14.22	3.27	16.99	0.760
1:39:24 PM	26.3	26.3	7.26	7.35	17.49	14.22	3.27	16.99	0.760
1:40:24 PM	26.3	26.3	7.27	7.36	17.10	13.90	3.20	16.60	0.743
1:41:24 PM	26.3	26.3	7.27	7.35	17.10	14.22	2.88	16.60	0.668
1:42:24 PM	26.3	26.3	7.27	7.36	17.10	13.90	3.20	16.60	0.743
1:43:24 PM	26.3	26.3	7.28	7.36	16.71	13.90	2.81	16.21	0.653
1:44:24 PM	26.3	26.3	7.28	7.36	16.71	13.90	2.81	16.21	0.653
1:45:24 PM	26.3	26.3	7.28	7.37	16.71	13.58	3.13	16.21	0.726
1:46:24 PM	26.3	26.3	7.28	7.37	16.71	13.58	3.13	16.21	0.726
1:47:24 PM	26.3	26.3	7.28	7.37	16.71	13.58	3.13	16.21	0.726
1:48:24 PM	26.3	26.3	7.29	7.37	16.33	13.58	2.75	15.83	0.638
1:49:24 PM	26.3	26.3	7.29	7.38	16.33	13.27	3.06	15.83	0.710
1:50:24 PM	26.3	26.3	7.30	7.38	15.96	13.27	2.68	15.46	0.623
1:51:24 PM	26.3	26.3	7.30	7.38	15.96	13.27	2.68	15.46	0.623
1:52:24 PM	26.3	26.3	7.30	7.39	15.96	12.97	2.99	15.46	0.693
1:53:24 PM	26.3	26.3	7.31	7.39	15.59	12.97	2.62	15.09	0.609
1:54:24 PM	26.3	26.3	7.31	7.39	15.59	12.97	2.62	15.09	0.609
1:55:24 PM	26.3	26.3	7.31	7.39	15.59	12.97	2.62	15.09	0.609
1:56:24 PM	26.3	26.3	7.31	7.40	15.59	12.67	2.92	15.09	0.678
1:57:24 PM	26.3	26.3	7.32	7.40	15.24	12.67	2.56	14.74	0.595
1:58:24 PM	26.3	26.3	7.32	7.40	15.24	12.67	2.56	14.74	0.595
1:59:24 PM	26.3	26.3	7.32	7.40	15.24	12.67	2.56	14.74	0.595
2:00:24 PM	26.3	26.3	7.32	7.41	15.24	12.39	2.85	14.74	0.662
2:01:24 PM	26.3	26.3	7.33	7.41	14.89	12.39	2.51	14.39	0.582
2:02:24 PM	26.3	26.3	7.33	7.41	14.89	12.39	2.51	14.39	0.582
2:03:24 PM	26.3	26.3	7.34	7.41	14.55	12.39	2.17	14.05	0.503
2:04:24 PM	26.3	26.3	7.34	7.42	14.55	12.10	2.45	14.05	0.568

10.2 cm air-lift_Trial 1_8/22/2008 (continued)

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		$C_t - C_{out}$	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
2:05:24 PM	26.3	26.3	7.34	7.42	14.55	12.10	2.45	14.05	0.568
2:06:24 PM	26.3	26.3	7.34	7.42	14.55	12.10	2.45	14.05	0.568
2:07:24 PM	26.3	26.3	7.35	7.42	14.22	12.10	2.12	13.72	0.491
2:08:24 PM	26.3	26.3	7.35	7.43	14.22	11.83	2.39	13.72	0.555
2:09:24 PM	26.3	26.3	7.35	7.43	14.22	11.83	2.39	13.72	0.555
2:10:24 PM	26.3	26.3	7.35	7.43	14.22	11.83	2.39	13.72	0.555
2:11:24 PM	26.3	26.3	7.36	7.43	13.90	11.83	2.07	13.40	0.480
2:12:24 PM	26.3	26.3	7.36	7.44	13.90	11.56	2.34	13.40	0.543
2:13:24 PM	26.3	26.3	7.36	7.44	13.90	11.56	2.34	13.40	0.543
2:14:24 PM	26.3	26.3	7.36	7.44	13.90	11.56	2.34	13.40	0.543
2:15:24 PM	26.3	26.3	7.37	7.44	13.58	11.56	2.02	13.08	0.469
2:16:24 PM	26.3	26.3	7.37	7.44	13.58	11.56	2.02	13.08	0.469
2:17:24 PM	26.3	26.3	7.37	7.45	13.58	11.30	2.28	13.08	0.530
2:18:24 PM	26.3	26.3	7.38	7.45	13.27	11.30	1.98	12.77	0.459
2:19:24 PM	26.3	26.3	7.38	7.45	13.27	11.30	1.98	12.77	0.459
2:20:24 PM	26.3	26.3	7.38	7.46	13.27	11.04	2.23	12.77	0.518
2:21:24 PM	26.3	26.3	7.39	7.46	12.97	11.04	1.93	12.47	0.448
2:22:24 PM	26.3	26.3	7.39	7.46	12.97	11.04	1.93	12.47	0.448
2:23:24 PM	26.3	26.3	7.39	7.46	12.97	11.04	1.93	12.47	0.448
2:24:24 PM	26.3	26.3	7.39	7.47	12.97	10.79	2.18	12.47	0.507
2:25:24 PM	26.3	26.3	7.40	7.47	12.67	10.79	1.89	12.17	0.438
2:26:24 PM	26.3	26.3	7.40	7.47	12.67	10.79	1.89	12.17	0.438
2:27:24 PM	26.3	26.3	7.40	7.47	12.67	10.79	1.89	12.17	0.438
2:28:24 PM	26.3	26.3	7.41	7.47	12.39	10.79	1.60	11.89	0.371
2:29:24 PM	26.3	26.3	7.41	7.48	12.39	10.54	1.84	11.89	0.428
2:30:24 PM	26.3	26.3	7.41	7.48	12.39	10.54	1.84	11.89	0.428
2:31:24 PM	26.3	26.3	7.41	7.48	12.39	10.54	1.84	11.89	0.428
2:32:24 PM	26.3	26.3	7.42	7.48	12.10	10.54	1.56	11.60	0.363
2:33:24 PM	26.3	26.3	7.42	7.49	12.10	10.30	1.80	11.60	0.418
2:34:24 PM	26.3	26.3	7.42	7.49	12.10	10.30	1.80	11.60	0.418
2:35:24 PM	26.3	26.3	7.42	7.49	12.10	10.30	1.80	11.60	0.418
2:36:24 PM	26.3	26.3	7.43	7.50	11.83	10.07	1.76	11.33	0.409
2:37:24 PM	26.3	26.3	7.43	7.50	11.83	10.07	1.76	11.33	0.409
2:38:24 PM	26.3	26.3	7.43	7.50	11.83	10.07	1.76	11.33	0.409
2:39:24 PM	26.3	26.3	7.43	7.50	11.83	10.07	1.76	11.33	0.409

10.2 cm air-lift_Trial 2_8/22/2008

Hydraulic and Alkalinity Summary

Time	Volume [liters]	Fill time [sec]	Q_L [l min^{-1}]	Alk [mg l^{-1}]
7:30 PM	20.06	7.25	166.01	155
7:45 PM	20.06	--	--	--
8:15 PM	20.06	7.19	167.40	156
8:45 PM	20.06	7.2	167.17	--
9:15 PM	20.06	--	--	154
10:00 PM	20.06	--	--	154
10:30 PM	20.06	7.22	166.70	154

Lift	30.5	cm	$Q_{L,ave}$	166.82	l min^{-1}
C_s	0.5	mg l^{-1}	$Q_{G,ave}$	170.00	l min^{-1}
FW_{CO2}	44.01	g mol^{-1}	Q_G:Q_L	1.02	
V_{tank}	7231.6	liters	Alkalinity	155	mg $CaCO_3$ l^{-1}

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		C_t - C_{out}	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
7:23:07 PM	26.2	26.2	7.60	7.62	7.95	7.59	0.36	7.45	0.086
7:28:07 PM	26.2	26.2	7.60	7.63	7.95	7.42	0.53	7.45	0.127
7:33:07 PM	26.2	26.2	7.60	7.63	7.95	7.42	0.53	7.45	0.127
7:38:07 PM	26.2	26.2	6.69	6.80	64.60	50.14	14.45	64.10	3.472
7:43:07 PM	26.2	26.2	6.69	6.81	64.60	49.00	15.60	64.10	3.746
7:48:07 PM	26.2	26.2	6.70	6.79	63.13	51.31	11.82	62.63	2.838
7:53:07 PM	26.2	26.2	6.72	6.80	60.29	50.14	10.14	59.79	2.436
7:58:07 PM	26.2	26.2	6.75	6.82	56.26	47.89	8.38	55.76	2.012
8:03:07 PM	26.2	26.2	6.75	6.84	56.26	45.73	10.53	55.76	2.530
8:08:07 PM	26.2	26.2	6.78	6.85	52.51	44.69	7.82	52.01	1.878
8:13:07 PM	26.2	26.2	6.79	6.87	51.31	42.68	8.63	50.81	2.074
8:18:07 PM	26.2	26.2	6.81	6.89	49.00	40.76	8.24	48.50	1.980
8:23:07 PM	26.2	26.2	6.83	6.91	46.80	38.92	7.87	46.30	1.891
8:28:07 PM	26.2	26.2	6.84	6.93	45.73	37.17	8.56	45.23	2.056
8:33:07 PM	26.2	26.2	6.87	6.95	42.68	35.50	7.18	42.18	1.725
8:38:07 PM	26.2	26.2	6.89	6.96	40.76	34.69	6.07	40.26	1.458

10.2 cm air-lift_Trial 2_8/22/2008 (continued)

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		$C_t - C_{out}$	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
8:43:07 PM	26.2	26.2	6.90	6.98	39.83	33.13	6.70	39.33	1.610
8:48:07 PM	26.2	26.2	6.92	7.00	38.04	31.64	6.40	37.54	1.537
8:53:07 PM	26.2	26.2	6.94	7.01	36.33	30.92	5.41	35.83	1.299
8:58:07 PM	26.2	26.2	6.95	7.02	35.50	30.22	5.28	35.00	1.269
9:03:07 PM	26.2	26.2	6.97	7.04	33.90	28.86	5.05	33.40	1.212
9:08:07 PM	26.2	26.2	6.98	7.06	33.13	27.56	5.57	32.63	1.339
9:13:07 PM	26.2	26.2	7.00	7.07	31.64	26.93	4.71	31.14	1.131
9:18:07 PM	26.2	26.2	7.02	7.09	30.22	25.72	4.50	29.72	1.080
9:23:07 PM	26.2	26.2	7.02	7.11	30.22	24.56	5.66	29.72	1.359
9:28:07 PM	26.2	26.2	7.04	7.12	28.86	24.00	4.85	28.36	1.166
9:33:07 PM	26.2	26.1	7.06	7.14	27.56	22.92	4.64	27.06	1.114
9:38:07 PM	26.2	26.1	7.07	7.15	26.93	22.40	4.53	26.43	1.088
9:43:07 PM	26.2	26.1	7.10	7.16	25.13	21.89	3.24	24.63	0.779
9:48:07 PM	26.2	26.1	7.11	7.18	24.56	20.90	3.66	24.06	0.878
9:53:07 PM	26.2	26.1	7.13	7.20	23.45	19.96	3.49	22.95	0.839
9:58:07 PM	26.2	26.1	7.15	7.21	22.40	19.51	2.89	21.90	0.694
10:03:07 PM	26.2	26.1	7.16	7.22	21.89	19.06	2.82	21.39	0.678
10:08:07 PM	26.2	26.1	7.17	7.24	21.39	18.21	3.18	20.89	0.765
10:13:07 PM	26.2	26.1	7.19	7.26	20.43	17.39	3.04	19.93	0.730
10:18:07 PM	26.2	26.1	7.19	7.27	20.43	16.99	3.44	19.93	0.826
10:23:07 PM	26.2	26.1	7.21	7.29	19.51	16.23	3.28	19.01	0.788
10:28:07 PM	26.2	26.1	7.23	7.30	18.63	15.86	2.77	18.13	0.666
10:33:07 PM	26.2	26.1	7.25	7.31	17.79	15.50	2.30	17.29	0.552
10:38:07 PM	26.2	26.1	7.26	7.33	17.39	14.80	2.59	16.89	0.622
10:43:07 PM	26.2	26.1	7.28	7.35	16.60	14.13	2.47	16.10	0.594
10:48:07 PM	26.2	26.1	7.29	7.36	16.23	13.81	2.42	15.73	0.580
10:53:07 PM	26.2	26.1	7.30	7.37	15.86	13.50	2.36	15.36	0.567
10:58:07 PM	26.2	26.1	7.31	7.38	15.50	13.19	2.31	15.00	0.554
11:03:07 PM	26.2	26.1	7.32	7.40	15.14	12.60	2.55	14.64	0.612
11:08:07 PM	26.2	26.1	7.37	7.42	13.50	12.03	1.47	13.00	0.353
11:13:07 PM	26.2	26.1	7.38	7.43	13.19	11.76	1.43	12.69	0.345
11:18:07 PM	26.1	26.1	7.38	7.44	13.19	11.49	1.70	12.69	0.409
11:23:07 PM	26.1	26.1	7.41	7.46	12.31	10.97	1.34	11.81	0.322
11:28:07 PM	26.1	26.1	7.42	7.47	12.03	10.72	1.31	11.53	0.314
11:33:07 PM	26.1	26.1	7.43	7.48	11.76	10.48	1.28	11.26	0.307

10.2 cm air-lift_Trial 2_8/22/2008 (continued)

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		$C_t - C_{out}$	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
11:38:07 PM	26.1	26.1	7.44	7.50	11.49	10.01	1.48	10.99	0.356
11:43:07 PM	26.1	26.1	7.46	7.51	10.97	9.78	1.19	10.47	0.287
11:48:07 PM	26.1	26.1	7.48	7.53	10.48	9.34	1.14	9.98	0.274
11:53:07 PM	26.1	26.1	7.49	7.54	10.24	9.12	1.11	9.74	0.267
11:58:07 PM	26.1	26.1	7.50	7.55	10.01	8.92	1.09	9.51	0.261
12:03:07 AM	26.1	26.1	7.51	7.56	9.78	8.71	1.06	9.28	0.255
12:08:07 AM	26.1	26.1	7.53	7.58	9.34	8.32	1.02	8.84	0.244
12:13:07 AM	26.1	26.1	7.53	7.59	9.34	8.13	1.20	8.84	0.289
12:18:07 AM	26.1	26.1	7.55	7.60	8.92	7.95	0.97	8.42	0.233
12:23:07 AM	26.1	26.1	7.57	7.61	8.52	7.77	0.75	8.02	0.180
12:28:07 AM	26.1	26.1	7.57	7.62	8.52	7.59	0.93	8.02	0.222
12:33:07 AM	26.1	26.1	7.59	7.64	8.13	7.25	0.88	7.63	0.212
12:38:07 AM	26.1	26.1	7.60	7.65	7.95	7.08	0.86	7.45	0.208
12:43:07 AM	26.1	26.1	7.61	7.66	7.77	6.92	0.84	7.27	0.203
12:48:07 AM	26.1	26.1	7.61	7.67	7.77	6.76	1.00	7.27	0.241
12:53:07 AM	26.1	26.1	7.63	7.68	7.42	6.61	0.81	6.92	0.194
12:58:07 AM	26.1	26.1	7.65	7.70	7.08	6.31	0.77	6.58	0.185
1:03:07 AM	26.1	26.1	7.65	7.71	7.08	6.17	0.91	6.58	0.220
1:08:07 AM	26.1	26.1	7.67	7.72	6.76	6.03	0.74	6.26	0.177
1:13:07 AM	26.1	26	7.68	7.73	6.61	5.89	0.72	6.11	0.173
1:18:07 AM	26.1	26	7.69	7.74	6.46	5.76	0.70	5.96	0.169
1:23:07 AM	26.1	26	7.69	7.75	6.46	5.63	0.83	5.96	0.200
1:28:07 AM	26.1	26	7.71	7.76	6.17	5.50	0.67	5.67	0.161
1:33:07 AM	26.1	26	7.72	7.77	6.03	5.37	0.66	5.53	0.157
1:38:07 AM	26.1	26	7.73	7.78	5.89	5.25	0.64	5.39	0.154
1:43:07 AM	26.1	26	7.74	7.79	5.76	5.13	0.63	5.26	0.150
1:48:07 AM	26.1	26	7.75	7.80	5.63	5.01	0.61	5.13	0.147
1:53:07 AM	26.1	26	7.76	7.81	5.50	4.90	0.60	5.00	0.144
1:58:07 AM	26.1	26	7.77	7.82	5.37	4.79	0.58	4.87	0.140
2:03:07 AM	26.1	26	7.77	7.82	5.37	4.79	0.58	4.87	0.140
2:08:07 AM	26.1	26	7.79	7.83	5.13	4.68	0.45	4.63	0.108
2:13:07 AM	26.1	26	7.80	7.84	5.01	4.57	0.44	4.51	0.106
2:18:07 AM	26.1	26	7.81	7.85	4.90	4.47	0.43	4.40	0.104
2:23:07 AM	26.1	26	7.81	7.86	4.90	4.37	0.53	4.40	0.128
2:28:07 AM	26.1	26	7.82	7.87	4.79	4.27	0.52	4.29	0.125

10.2 cm air-lift_Trial 2_8/22/2008 (continued)

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		$C_t - C_{out}$	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
2:33:07 AM	26.1	26	7.83	7.88	4.68	4.17	0.51	4.18	0.122
2:38:07 AM	26.1	26	7.84	7.88	4.57	4.17	0.40	4.07	0.097
2:43:07 AM	26.1	26	7.84	7.89	4.57	4.08	0.50	4.07	0.119
2:48:07 AM	26	26	7.86	7.90	4.37	3.98	0.38	3.87	0.092
2:53:07 AM	26	26	7.86	7.91	4.37	3.89	0.47	3.87	0.114
2:58:07 AM	26	26	7.87	7.92	4.27	3.80	0.46	3.77	0.111
3:03:07 AM	26	26	7.88	7.92	4.17	3.80	0.37	3.67	0.088
3:08:07 AM	26	26	7.88	7.93	4.17	3.72	0.45	3.67	0.109
3:13:07 AM	26	26	7.89	7.94	4.08	3.63	0.44	3.58	0.106
3:18:07 AM	26	26	7.90	7.94	3.98	3.63	0.35	3.48	0.084

10.2 cm air-lift_Trial 3_8/23/2008

Hydraulic and Alkalinity Summary

Time	Volume [liters]	Fill time [sec]	Q_L [l min^{-1}]	Alk [mg l^{-1}]
10:15 AM	20.06	7.21	166.93	153
10:50 AM	20.06	7.30	164.88	155.00
11:15 AM	20.06	7.35	163.76	157
11:45 AM	20.06	--	--	--
1:00 PM	20.06	7.23	166.47	156
2:00 PM	20.06	--	--	--
2:30 PM	20.06	7.27	165.56	155

Lift	30.5	cm	$Q_{L,ave}$	165.52	l min^{-1}
C_s	0.5	mg l^{-1}	$Q_{G,ave}$	170.00	l min^{-1}
FW_{CO2}	44.01	g mol^{-1}	Q_G:Q_L	1.03	
V_{tank}	7231.6	liters	Alkalinity	155	mg $CaCO_3$ l^{-1}

10.2 cm air-lift_Trial 3_8/23/2008 (continued)

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		$C_t - C_{out}$	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
10:13:21 AM	26	26	8.22	8.24	1.91	1.83	0.09	1.41	0.021
10:13:30 AM	26	26	8.22	8.24	1.91	1.83	0.09	1.41	0.021
10:13:40 AM	26	26	8.22	8.24	1.91	1.83	0.09	1.41	0.021
10:15:14 AM	26	26	8.21	7.69	1.96	6.48	-4.53	1.46	-1.079
10:15:24 AM	26	26	7.59	7.40	8.16	12.64	-4.48	7.66	-1.068
10:15:34 AM	26	26	7.52	7.12	9.59	24.09	-14.50	9.09	-3.456
10:15:44 AM	26	26	7.52	7.04	9.59	28.97	-19.38	9.09	-4.618
10:15:54 AM	26	26	7.28	6.96	16.67	34.83	-18.16	16.17	-4.328
10:16:04 AM	26	26	7.24	6.96	18.28	34.83	-16.55	17.78	-3.944
10:16:15 AM	26	26	7.20	6.92	20.04	38.19	-18.15	19.54	-4.325
10:16:24 AM	26	26	7.14	6.80	23.01	50.34	-27.33	22.51	-6.514
10:16:34 AM	26	26	7.03	6.77	29.64	53.94	-24.30	29.14	-5.791
10:16:44 AM	26	26	6.94	6.73	36.47	59.14	-22.68	35.97	-5.405
10:16:54 AM	26	26	6.91	7.87	39.08	4.28	34.79	38.58	8.292
10:17:18 AM	26	26	6.80	6.83	50.34	46.98	3.36	49.84	0.801
10:22:18 AM	26	26	6.77	6.89	53.94	40.92	13.02	53.44	3.104
10:27:18 AM	26	26	6.79	6.91	51.51	39.08	12.44	51.01	2.964
10:32:18 AM	26	26	6.81	6.93	49.19	37.32	11.88	48.69	2.831
10:37:18 AM	26	26	6.83	6.96	46.98	34.83	12.15	46.48	2.897
10:42:18 AM	26	26	6.85	6.97	44.86	34.03	10.83	44.36	2.582
10:47:18 AM	26	26	6.87	6.99	42.85	32.50	10.34	42.35	2.465
10:52:18 AM	26	26	6.89	7.00	40.92	31.76	9.16	40.42	2.182
10:57:18 AM	26	26	6.91	7.02	39.08	30.33	8.74	38.58	2.084
11:02:18 AM	26	26	6.92	7.03	38.19	29.64	8.54	37.69	2.037
11:07:18 AM	26.1	26	6.94	7.05	36.47	28.31	8.16	35.97	1.945
11:12:18 AM	26.1	26	6.95	7.06	35.64	27.66	7.97	35.14	1.901
11:17:18 AM	26.1	26	6.97	7.08	34.03	26.42	7.62	33.53	1.815
11:22:18 AM	26.1	26	6.99	7.09	32.50	25.82	6.68	32.00	1.593
11:27:18 AM	26.1	26	7.00	7.11	31.76	24.66	7.11	31.26	1.694
11:32:18 AM	26.1	26	7.02	7.13	30.33	23.55	6.79	29.83	1.618
11:37:18 AM	26.1	26	7.03	7.14	29.64	23.01	6.63	29.14	1.581
11:42:18 AM	26.1	26	7.05	7.15	28.31	22.49	5.82	27.81	1.388
11:47:18 AM	26.1	26	7.06	7.17	27.66	21.47	6.19	27.16	1.475
11:52:18 AM	26.1	26.1	7.08	7.18	26.42	20.98	5.43	25.92	1.295
11:57:18 AM	26.1	26.1	7.10	7.20	25.23	20.04	5.19	24.73	1.237

10.2 cm air-lift_Trial 3_8/23/2008 (continued)

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		$C_t - C_{out}$	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
12:02:18 PM	26.1	26.1	7.11	7.21	24.66	19.58	5.07	24.16	1.209
12:07:18 PM	26.1	26.1	7.12	7.22	24.09	19.14	4.96	23.59	1.181
12:12:18 PM	26.1	26.1	7.14	7.24	23.01	18.28	4.73	22.51	1.128
12:17:18 PM	26.1	26.1	7.15	7.25	22.49	17.86	4.62	21.99	1.102
12:22:18 PM	26.1	26.1	7.17	7.26	21.47	17.45	4.02	20.97	0.958
12:27:18 PM	26.1	26.1	7.19	7.28	20.51	16.67	3.84	20.01	0.915
12:32:18 PM	26.1	26.1	7.20	7.29	20.04	16.29	3.75	19.54	0.894
12:37:18 PM	26.1	26.1	7.21	7.31	19.58	15.56	4.03	19.08	0.960
12:42:18 PM	26.1	26.1	7.23	7.32	18.70	15.20	3.50	18.20	0.834
12:47:18 PM	26.2	26.1	7.24	7.34	18.28	14.52	3.76	17.78	0.896
12:52:18 PM	26.2	26.1	7.26	7.35	17.45	14.19	3.27	16.95	0.779
12:57:18 PM	26.2	26.1	7.27	7.36	17.06	13.86	3.19	16.56	0.761
1:02:18 PM	26.2	26.1	7.29	7.37	16.29	13.55	2.74	15.79	0.653
1:07:18 PM	26.2	26.1	7.30	7.39	15.92	12.94	2.98	15.42	0.710
1:12:18 PM	26.2	26.1	7.31	7.39	15.56	12.94	2.62	15.06	0.624
1:17:18 PM	26.2	26.1	7.32	7.40	15.20	12.64	2.56	14.70	0.610
1:22:18 PM	26.2	26.1	7.35	7.42	14.19	12.08	2.11	13.69	0.503
1:27:18 PM	26.2	26.2	7.35	7.43	14.19	11.80	2.39	13.69	0.569
1:32:18 PM	26.2	26.2	7.36	7.44	13.86	11.53	2.33	13.36	0.556
1:37:18 PM	26.2	26.2	7.37	7.46	13.55	11.01	2.54	13.05	0.604
1:42:18 PM	26.2	26.2	7.38	7.46	13.24	11.01	2.23	12.74	0.531
1:47:18 PM	26.2	26.2	7.40	7.48	12.64	10.52	2.13	12.14	0.507
1:52:18 PM	26.2	26.2	7.41	7.49	12.36	10.28	2.08	11.86	0.495
1:57:18 PM	26.2	26.2	7.43	7.50	11.80	10.04	1.76	11.30	0.419
2:02:18 PM	26.2	26.2	7.44	7.51	11.53	9.82	1.72	11.03	0.409
2:07:18 PM	26.2	26.2	7.46	7.53	11.01	9.37	1.64	10.51	0.391
2:12:18 PM	26.2	26.2	7.47	7.54	10.76	9.16	1.60	10.26	0.382
2:17:18 PM	26.3	26.2	7.48	7.55	10.52	8.95	1.57	10.02	0.373
2:22:18 PM	26.3	26.2	7.50	7.57	10.04	8.55	1.50	9.54	0.356

pH/Alkalinity CTR and $C_{deficit}$ Linear Regression Summary for 170 l min^{-1} air injection

Air-lift [cm]	Trial	Lift [cm]	CTR Coefficient for $C_{deficit}$ equations	R^2
10.2	1	30.5	$CTR = 0.0382*C_{deficit}$	0.955
10.2	2	30.5	$CTR = 0.0393*C_{deficit}$	0.972
10.2	3	30.5	$CTR = 0.0541*C_{deficit}$	0.963

pH/Alkalinity K_La and SCTR Summary for 170 l min^{-1} air injection

		K_La [min^{-1}]		K_La_{20} [min^{-1}]		SCTR [kg hr^{-1}]	
Air-lift [cm]	**Trial**	**Inlet**	**Outlet**	**Inlet**	**Outlet**	**Inlet**	**Outlet**
10.2	1	0.008	0.008	0.007	0.007	0.0015	0.0016
10.2	2	0.007	0.006	0.006	0.005	0.0012	0.0012
10.2	3	0.007	0.007	0.006	0.006	0.0013	0.0012
	Ave	**0.007**	**0.007**	**0.006**	**0.006**	**0.0014**	**0.0013**
	St. D.	**0.001**	**0.001**	**0.001**	**0.001**	**0.0002**	**0.0002**

DEGASSING STUDIES_pH/Alkalinity Method (continued)

15.2 cm air-lift_340 l air min^{-1}

15.2 cm air-lift_Trial 1_8/23/2008

Hydraulic and Alkalinity Summary

Time	Volume [liters]	Fill time [sec]	Q_L [l min^{-1}]	Alk [mg l^{-1}]
5:10 PM	20.06	3.41	352.96	153
5:30 PM	20.06	3.44	349.88	154
6:00 PM	20.06	3.56	338.09	158
7:00 PM	20.06	3.52	341.93	156

Lift	30.5	cm	$Q_{L,ave}$	345.72	l min^{-1}
C_s	0.5	mg l^{-1}	$Q_{G,ave}$	340.00	l min^{-1}
FW_{CO2}	44.01	g mol^{-1}	Q_G:Q_L	0.98	
V_{tank}	8066	liters	Alkalinity	155	mg $CaCO_3$ l^{-1}

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		C_t - C_{out}	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
5:27:22 PM	26.3	26.3	6.92	6.87	38.20	42.86	-4.66	37.70	-2.320
5:27:32 PM	26.3	26.3	6.90	6.85	40.00	44.88	-4.88	39.50	-2.430
5:27:42 PM	26.3	26.3	6.86	6.81	43.86	49.21	-5.35	43.36	-2.664
5:27:52 PM	26.3	26.3	6.84	6.69	45.92	64.87	-18.95	45.42	-9.432
5:28:03 PM	26.3	26.3	6.85	6.83	44.88	46.99	-2.12	44.38	-1.053
5:28:12 PM	26.3	26.3	6.83	6.86	46.99	43.86	3.14	46.49	1.562
5:28:22 PM	26.3	26.3	6.81	6.80	49.21	50.36	-1.15	48.71	-0.571
5:28:32 PM	26.3	26.3	6.79	6.78	51.53	52.73	-1.20	51.03	-0.598
5:28:44 PM	26.3	26.3	6.77	6.78	53.96	52.73	1.23	53.46	0.611
5:28:52 PM	26.3	26.3	6.76	6.79	55.21	51.53	3.69	54.71	1.835
5:29:18 PM	26.3	26.3	6.78	6.80	52.73	50.36	2.37	52.23	1.181
5:30:18 PM	26.3	26.3	6.76	6.82	55.21	48.09	7.12	54.71	3.547
5:31:18 PM	26.3	26.3	6.76	6.82	55.21	48.09	7.12	54.71	3.547
5:32:18 PM	26.3	26.3	6.77	6.83	53.96	46.99	6.96	53.46	3.466
5:33:18 PM	26.3	26.3	6.78	6.84	52.73	45.92	6.80	52.23	3.387
5:34:18 PM	26.3	26.3	6.79	6.85	51.53	44.88	6.65	51.03	3.310
5:35:18 PM	26.3	26.3	6.80	6.86	50.36	43.86	6.50	49.86	3.235

15.2 cm air-lift_Trial 1_8/23/2008 (continued)

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		$C_t - C_{out}$	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
5:36:18 PM	26.3	26.3	6.81	6.87	49.21	42.86	6.35	48.71	3.161
5:37:18 PM	26.3	26.3	6.81	6.88	49.21	41.88	7.33	48.71	3.647
5:38:18 PM	26.3	26.3	6.82	6.88	48.09	41.88	6.21	47.59	3.089
5:39:18 PM	26.3	26.3	6.83	6.90	46.99	40.00	7.00	46.49	3.483
5:40:18 PM	26.3	26.3	6.84	6.91	45.92	39.09	6.84	45.42	3.403
5:41:18 PM	26.3	26.3	6.85	6.92	44.88	38.20	6.68	44.38	3.326
5:42:18 PM	26.3	26.3	6.86	6.92	43.86	38.20	5.66	43.36	2.817
5:43:18 PM	26.3	26.3	6.87	6.93	42.86	37.33	5.53	42.36	2.753
5:44:18 PM	26.3	26.3	6.88	6.94	41.88	36.48	5.40	41.38	2.691
5:45:18 PM	26.3	26.3	6.89	6.95	40.93	35.65	5.28	40.43	2.629
5:46:18 PM	26.3	26.3	6.90	6.96	40.00	34.84	5.16	39.50	2.569
5:47:18 PM	26.3	26.3	6.91	6.98	39.09	33.27	5.82	38.59	2.897
5:48:18 PM	26.3	26.3	6.91	6.98	39.09	33.27	5.82	38.59	2.897
5:49:18 PM	26.3	26.3	6.92	6.99	38.20	32.51	5.69	37.70	2.831
5:50:18 PM	26.3	26.3	6.93	7.00	37.33	31.77	5.56	36.83	2.766
5:51:18 PM	26.3	26.3	6.94	7.01	36.48	31.05	5.43	35.98	2.703
5:52:18 PM	26.3	26.3	6.95	7.02	35.65	30.34	5.31	35.15	2.642
5:53:18 PM	26.3	26.3	6.96	7.03	34.84	29.65	5.19	34.34	2.582
5:54:18 PM	26.3	26.3	6.97	7.04	34.04	28.98	5.07	33.54	2.523
5:55:18 PM	26.3	26.3	6.97	7.05	34.04	28.32	5.73	33.54	2.851
5:56:18 PM	26.3	26.3	6.98	7.06	33.27	27.67	5.60	32.77	2.786
5:57:18 PM	26.3	26.3	6.99	7.07	32.51	27.04	5.47	32.01	2.723
5:58:18 PM	26.3	26.3	7.00	7.08	31.77	26.43	5.35	31.27	2.661
5:59:18 PM	26.3	26.3	7.01	7.09	31.05	25.83	5.22	30.55	2.600
6:00:18 PM	26.3	26.3	7.02	7.10	30.34	25.24	5.10	29.84	2.541
6:01:18 PM	26.3	26.3	7.03	7.10	29.65	25.24	4.41	29.15	2.197
6:02:18 PM	26.3	26.3	7.04	7.11	28.98	24.66	4.31	28.48	2.147
6:03:18 PM	26.3	26.3	7.05	7.12	28.32	24.10	4.22	27.82	2.099
6:04:18 PM	26.3	26.3	7.06	7.14	27.67	23.02	4.66	27.17	2.318
6:05:18 PM	26.3	26.3	7.07	7.14	27.04	23.02	4.03	26.54	2.004
6:06:18 PM	26.3	26.3	7.08	7.15	26.43	22.49	3.93	25.93	1.958
6:07:18 PM	26.3	26.3	7.09	7.16	25.83	21.98	3.84	25.33	1.914
6:08:18 PM	26.3	26.3	7.10	7.17	25.24	21.48	3.76	24.74	1.870
6:09:18 PM	26.3	26.3	7.11	7.18	24.66	20.99	3.67	24.16	1.828
6:10:18 PM	26.3	26.3	7.12	7.19	24.10	20.51	3.59	23.60	1.786

15.2 cm air-lift_Trial 1_8/23/2008 (continued)

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		$C_t - C_{out}$	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
6:11:18 PM	26.3	26.3	7.13	7.19	23.55	20.51	3.04	23.05	1.513
6:12:18 PM	26.3	26.3	7.14	7.20	23.02	20.05	2.97	22.52	1.479
6:13:18 PM	26.3	26.3	7.15	7.21	22.49	19.59	2.90	21.99	1.445
6:14:18 PM	26.3	26.3	7.15	7.22	22.49	19.14	3.35	21.99	1.667
6:15:18 PM	26.3	26.3	7.16	7.23	21.98	18.71	3.27	21.48	1.629
6:16:18 PM	26.3	26.3	7.17	7.24	21.48	18.28	3.20	20.98	1.592
6:17:18 PM	26.3	26.3	7.18	7.25	20.99	17.87	3.12	20.49	1.556
6:18:18 PM	26.3	26.3	7.19	7.26	20.51	17.46	3.05	20.01	1.520
6:19:18 PM	26.3	26.3	7.20	7.27	20.05	17.06	2.98	19.55	1.486
6:20:18 PM	26.3	26.3	7.21	7.27	19.59	17.06	2.53	19.09	1.258
6:21:18 PM	26.3	26.3	7.21	7.28	19.59	16.67	2.92	19.09	1.452
6:22:18 PM	26.3	26.3	7.22	7.29	19.14	16.29	2.85	18.64	1.419
6:23:18 PM	26.3	26.3	7.24	7.30	18.28	15.92	2.36	17.78	1.174
6:24:18 PM	26.3	26.3	7.24	7.31	18.28	15.56	2.72	17.78	1.355
6:25:18 PM	26.3	26.3	7.25	7.32	17.87	15.21	2.66	17.37	1.324
6:26:18 PM	26.3	26.3	7.26	7.33	17.46	14.86	2.60	16.96	1.294
6:27:18 PM	26.3	26.3	7.27	7.33	17.06	14.86	2.20	16.56	1.096
6:28:18 PM	26.3	26.3	7.28	7.34	16.67	14.52	2.15	16.17	1.071
6:29:18 PM	26.3	26.3	7.29	7.36	16.29	13.87	2.43	15.79	1.208
6:30:18 PM	26.3	26.3	7.30	7.36	15.92	13.87	2.05	15.42	1.023
6:31:18 PM	26.3	26.3	7.30	7.37	15.92	13.55	2.37	15.42	1.180
6:32:18 PM	26.3	26.3	7.31	7.38	15.56	13.24	2.32	15.06	1.153
6:33:18 PM	26.3	26.3	7.32	7.39	15.21	12.94	2.26	14.71	1.127
6:34:18 PM	26.3	26.3	7.33	7.39	14.86	12.94	1.92	14.36	0.955
6:35:18 PM	26.3	26.3	7.34	7.40	14.52	12.65	1.87	14.02	0.933
6:36:18 PM	26.3	26.3	7.35	7.41	14.19	12.36	1.83	13.69	0.912
6:37:18 PM	26.3	26.3	7.36	7.42	13.87	12.08	1.79	13.37	0.891
6:38:18 PM	26.3	26.3	7.36	7.42	13.87	12.08	1.79	13.37	0.891
6:39:18 PM	26.3	26.3	7.37	7.44	13.55	11.54	2.02	13.05	1.004
6:40:18 PM	26.3	26.3	7.38	7.44	13.24	11.54	1.71	12.74	0.851
6:41:18 PM	26.3	26.3	7.39	7.45	12.94	11.27	1.67	12.44	0.831
6:42:18 PM	26.3	26.3	7.40	7.46	12.65	11.02	1.63	12.15	0.813
6:43:18 PM	26.3	26.3	7.41	7.47	12.36	10.77	1.59	11.86	0.794
6:44:18 PM	26.3	26.3	7.41	7.47	12.36	10.77	1.59	11.86	0.794
6:45:18 PM	26.3	26.3	7.42	7.48	12.08	10.52	1.56	11.58	0.776

15.2 cm air-lift_Trial 1_8/23/2008 (continued)

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		$C_t - C_{out}$	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
6:46:18 PM	26.3	26.3	7.43	7.49	11.80	10.28	1.52	11.30	0.758
6:47:18 PM	26.3	26.3	7.44	7.50	11.54	10.05	1.49	11.04	0.741
6:48:18 PM	26.3	26.3	7.44	7.51	11.54	9.82	1.72	11.04	0.855
6:49:18 PM	26.3	26.3	7.45	7.51	11.27	9.82	1.45	10.77	0.724
6:50:18 PM	26.3	26.3	7.46	7.52	11.02	9.60	1.42	10.52	0.708
6:51:18 PM	26.3	26.3	7.47	7.53	10.77	9.38	1.39	10.27	0.692
6:52:18 PM	26.3	26.2	7.47	7.54	10.77	9.16	1.60	10.27	0.798
6:53:18 PM	26.3	26.2	7.48	7.54	10.52	9.16	1.36	10.02	0.676
6:54:18 PM	26.3	26.2	7.49	7.55	10.28	8.95	1.33	9.78	0.660
6:55:18 PM	26.3	26.2	7.50	7.56	10.05	8.75	1.30	9.55	0.645
6:56:18 PM	26.3	26.2	7.51	7.56	9.82	8.75	1.07	9.32	0.532
6:57:18 PM	26.3	26.2	7.51	7.58	9.82	8.36	1.46	9.32	0.728
6:58:18 PM	26.3	26.2	7.52	7.58	9.60	8.36	1.24	9.10	0.616
6:59:18 PM	26.3	26.2	7.53	7.59	9.38	8.17	1.21	8.88	0.602
7:00:18 PM	26.3	26.2	7.54	7.60	9.16	7.98	1.18	8.66	0.589
7:01:18 PM	26.3	26.2	7.54	7.60	9.16	7.98	1.18	8.66	0.589
7:02:18 PM	26.3	26.2	7.55	7.61	8.95	7.80	1.16	8.45	0.575
7:03:18 PM	26.3	26.2	7.56	7.62	8.75	7.62	1.13	8.25	0.562
7:04:18 PM	26.3	26.2	7.57	7.62	8.55	7.62	0.93	8.05	0.463
7:05:18 PM	26.3	26.2	7.57	7.63	8.55	7.45	1.10	8.05	0.549
7:06:18 PM	26.3	26.2	7.58	7.63	8.36	7.45	0.91	7.86	0.452
7:07:18 PM	26.3	26.2	7.59	7.64	8.17	7.28	0.89	7.67	0.442
7:08:18 PM	26.3	26.2	7.59	7.65	8.17	7.11	1.05	7.67	0.525
7:09:18 PM	26.3	26.2	7.60	7.66	7.98	6.95	1.03	7.48	0.513
7:10:18 PM	26.3	26.2	7.61	7.67	7.80	6.79	1.01	7.30	0.501
7:11:18 PM	26.3	26.2	7.62	7.67	7.62	6.79	0.83	7.12	0.413
7:12:18 PM	26.3	26.2	7.62	7.68	7.62	6.64	0.98	7.12	0.490
7:13:18 PM	26.3	26.2	7.63	7.69	7.45	6.49	0.96	6.95	0.478
7:14:18 PM	26.3	26.2	7.64	7.69	7.28	6.49	0.79	6.78	0.394
7:15:18 PM	26.3	26.2	7.64	7.70	7.28	6.34	0.94	6.78	0.468
7:16:18 PM	26.3	26.2	7.65	7.70	7.11	6.34	0.77	6.61	0.385
7:17:18 PM	26.3	26.2	7.66	7.71	6.95	6.20	0.76	6.45	0.376
7:18:18 PM	26.3	26.2	7.66	7.72	6.95	6.05	0.90	6.45	0.447
7:19:18 PM	26.3	26.2	7.67	7.72	6.79	6.05	0.74	6.29	0.368
7:20:18 PM	26.3	26.2	7.68	7.73	6.64	5.92	0.72	6.14	0.359

15.2 cm air-lift_Trial 1_8/23/2008 (continued)

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		$C_t - C_{out}$	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
7:21:18 PM	26.3	26.2	7.68	7.74	6.64	5.78	0.86	6.14	0.426
7:22:18 PM	26.3	26.2	7.69	7.74	6.49	5.78	0.71	5.99	0.351
7:23:18 PM	26.3	26.2	7.69	7.75	6.49	5.65	0.84	5.99	0.417
7:24:18 PM	26.3	26.2	7.70	7.75	6.34	5.65	0.69	5.84	0.343
7:25:18 PM	26.3	26.2	7.71	7.76	6.20	5.52	0.67	5.70	0.335
7:26:18 PM	26.3	26.2	7.71	7.76	6.20	5.52	0.67	5.70	0.335
7:27:18 PM	26.3	26.2	7.72	7.77	6.05	5.40	0.66	5.55	0.328
7:28:18 PM	26.3	26.2	7.72	7.78	6.05	5.27	0.78	5.55	0.389
7:29:18 PM	26.3	26.2	7.73	7.78	5.92	5.27	0.64	5.42	0.320
7:30:18 PM	26.3	26.2	7.74	7.79	5.78	5.15	0.63	5.28	0.313
7:31:18 PM	26.3	26.2	7.74	7.79	5.78	5.15	0.63	5.28	0.313
7:32:18 PM	26.3	26.2	7.75	7.80	5.65	5.04	0.61	5.15	0.306
7:33:18 PM	26.3	26.2	7.75	7.80	5.65	5.04	0.61	5.15	0.306
7:34:18 PM	26.3	26.2	7.76	7.81	5.52	4.92	0.60	5.02	0.299
7:35:18 PM	26.3	26.2	7.77	7.82	5.40	4.81	0.59	4.90	0.292
7:36:18 PM	26.3	26.2	7.77	7.82	5.40	4.81	0.59	4.90	0.292
7:37:18 PM	26.3	26.2	7.78	7.83	5.27	4.70	0.57	4.77	0.285
7:38:18 PM	26.3	26.2	7.78	7.83	5.27	4.70	0.57	4.77	0.285
7:39:18 PM	26.3	26.2	7.79	7.83	5.15	4.70	0.45	4.65	0.226
7:40:18 PM	26.3	26.2	7.79	7.84	5.15	4.59	0.56	4.65	0.279
7:41:18 PM	26.3	26.2	7.80	7.85	5.04	4.49	0.55	4.54	0.273
7:42:18 PM	26.3	26.2	7.80	7.85	5.04	4.49	0.55	4.54	0.273
7:43:18 PM	26.3	26.2	7.81	7.86	4.92	4.39	0.54	4.42	0.266
7:44:18 PM	26.3	26.2	7.81	7.86	4.92	4.39	0.54	4.42	0.266
7:45:18 PM	26.3	26.2	7.82	7.86	4.81	4.39	0.42	4.31	0.211
7:46:18 PM	26.3	26.2	7.82	7.87	4.81	4.29	0.52	4.31	0.260
7:47:18 PM	26.2	26.2	7.83	7.87	4.70	4.29	0.41	4.20	0.206
7:48:18 PM	26.2	26.2	7.83	7.88	4.70	4.19	0.51	4.20	0.254
7:49:18 PM	26.2	26.2	7.84	7.88	4.59	4.19	0.40	4.09	0.201
7:50:18 PM	26.2	26.2	7.84	7.89	4.59	4.09	0.50	4.09	0.249
7:51:18 PM	26.2	26.2	7.85	7.89	4.49	4.09	0.39	3.99	0.197
7:52:18 PM	26.2	26.2	7.85	7.90	4.49	4.00	0.49	3.99	0.243
7:53:18 PM	26.2	26.2	7.86	7.90	4.39	4.00	0.39	3.89	0.192
7:54:18 PM	26.2	26.2	7.86	7.91	4.39	3.91	0.48	3.89	0.237
7:55:18 PM	26.2	26.2	7.86	7.91	4.39	3.91	0.48	3.89	0.237

15.2 cm air-lift_Trial 1_8/23/2008 (continued)

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		$C_t - C_{out}$	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
7:56:18 PM	26.2	26.2	7.87	7.91	4.29	3.91	0.38	3.79	0.188
7:57:18 PM	26.2	26.2	7.87	7.92	4.29	3.82	0.47	3.79	0.232
7:58:18 PM	26.2	26.2	7.88	7.92	4.19	3.82	0.37	3.69	0.183
7:59:18 PM	26.2	26.2	7.88	7.93	4.19	3.73	0.46	3.69	0.227
8:00:18 PM	26.2	26.2	7.89	7.93	4.09	3.73	0.36	3.59	0.179
8:01:18 PM	26.2	26.2	7.89	7.94	4.09	3.65	0.45	3.59	0.222
8:02:18 PM	26.2	26.2	7.89	7.94	4.09	3.65	0.45	3.59	0.222
8:03:18 PM	26.2	26.2	7.90	7.94	4.00	3.65	0.35	3.50	0.175
8:04:18 PM	26.2	26.2	7.90	7.95	4.00	3.56	0.43	3.50	0.217
8:05:18 PM	26.2	26.2	7.91	7.95	3.91	3.56	0.34	3.41	0.171
8:06:18 PM	26.2	26.2	7.91	7.96	3.91	3.48	0.43	3.41	0.212
8:07:18 PM	26.2	26.2	7.92	7.96	3.82	3.48	0.34	3.32	0.167
8:08:18 PM	26.2	26.2	7.92	7.96	3.82	3.48	0.34	3.32	0.167
8:09:18 PM	26.2	26.2	7.92	7.97	3.82	3.40	0.42	3.32	0.207
8:10:18 PM	26.2	26.2	7.93	7.97	3.73	3.40	0.33	3.23	0.164
8:11:18 PM	26.2	26.2	7.93	7.97	3.73	3.40	0.33	3.23	0.164
8:12:18 PM	26.2	26.2	7.93	7.98	3.73	3.33	0.41	3.23	0.202
8:13:18 PM	26.2	26.2	7.94	7.98	3.65	3.33	0.32	3.15	0.160
8:14:18 PM	26.2	26.2	7.94	7.98	3.65	3.33	0.32	3.15	0.160
8:15:18 PM	26.2	26.2	7.94	7.99	3.65	3.25	0.40	3.15	0.197
8:16:18 PM	26.2	26.2	7.95	7.99	3.56	3.25	0.31	3.06	0.156
8:17:18 PM	26.2	26.2	7.95	7.99	3.56	3.25	0.31	3.06	0.156
8:18:18 PM	26.2	26.2	7.95	8.00	3.56	3.18	0.39	3.06	0.193
8:19:18 PM	26.2	26.2	7.96	8.00	3.48	3.18	0.31	2.98	0.153
8:20:18 PM	26.2	26.2	7.96	8.00	3.48	3.18	0.31	2.98	0.153
8:21:18 PM	26.2	26.2	7.97	8.01	3.40	3.10	0.30	2.90	0.149
8:22:18 PM	26.2	26.2	7.97	8.01	3.40	3.10	0.30	2.90	0.149
8:23:18 PM	26.2	26.2	7.97	8.01	3.40	3.10	0.30	2.90	0.149
8:24:18 PM	26.2	26.2	7.98	8.02	3.33	3.03	0.29	2.83	0.146
8:25:18 PM	26.2	26.2	7.98	8.02	3.33	3.03	0.29	2.83	0.146
8:26:18 PM	26.2	26.2	7.98	8.02	3.33	3.03	0.29	2.83	0.146
8:27:18 PM	26.2	26.2	7.98	8.03	3.33	2.97	0.36	2.83	0.180
8:28:18 PM	26.2	26.2	7.99	8.03	3.25	2.97	0.29	2.75	0.142
8:29:18 PM	26.2	26.2	7.99	8.03	3.25	2.97	0.29	2.75	0.142
8:30:18 PM	26.2	26.2	7.99	8.03	3.25	2.97	0.29	2.75	0.142

15.2 cm air-lift_Trial 1_8/23/2008 (continued)

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		$C_t - C_{out}$	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
8:31:18 PM	26.2	26.2	8.00	8.04	3.18	2.90	0.28	2.68	0.139
8:32:18 PM	26.2	26.2	8.00	8.04	3.18	2.90	0.28	2.68	0.139
8:33:18 PM	26.2	26.2	8.00	8.04	3.18	2.90	0.28	2.68	0.139
8:34:18 PM	26.2	26.2	8.01	8.05	3.10	2.83	0.27	2.60	0.136
8:35:18 PM	26.2	26.2	8.01	8.05	3.10	2.83	0.27	2.60	0.136
8:36:18 PM	26.2	26.2	8.01	8.05	3.10	2.83	0.27	2.60	0.136
8:37:18 PM	26.2	26.2	8.01	8.05	3.10	2.83	0.27	2.60	0.136
8:38:18 PM	26.2	26.2	8.02	8.06	3.03	2.77	0.27	2.53	0.133
8:39:18 PM	26.2	26.2	8.02	8.06	3.03	2.77	0.27	2.53	0.133
8:40:18 PM	26.2	26.2	8.02	8.06	3.03	2.77	0.27	2.53	0.133
8:41:18 PM	26.2	26.2	8.02	8.07	3.03	2.70	0.33	2.53	0.164
8:42:18 PM	26.2	26.2	8.03	8.07	2.97	2.70	0.26	2.47	0.130
8:43:18 PM	26.2	26.2	8.03	8.07	2.97	2.70	0.26	2.47	0.130
8:44:18 PM	26.2	26.2	8.03	8.07	2.97	2.70	0.26	2.47	0.130
8:45:18 PM	26.2	26.2	8.04	8.08	2.90	2.64	0.25	2.40	0.127
8:46:18 PM	26.2	26.2	8.04	8.08	2.90	2.64	0.25	2.40	0.127
8:47:18 PM	26.2	26.2	8.04	8.08	2.90	2.64	0.25	2.40	0.127
8:48:18 PM	26.2	26.2	8.04	8.08	2.90	2.64	0.25	2.40	0.127
8:49:18 PM	26.2	26.2	8.04	8.09	2.90	2.58	0.32	2.40	0.157
8:50:18 PM	26.2	26.2	8.05	8.09	2.83	2.58	0.25	2.33	0.124
8:51:18 PM	26.2	26.2	8.05	8.09	2.83	2.58	0.25	2.33	0.124
8:52:18 PM	26.2	26.1	8.05	8.09	2.83	2.58	0.25	2.33	0.124
8:53:18 PM	26.2	26.1	8.05	8.10	2.83	2.52	0.31	2.33	0.153
8:54:18 PM	26.2	26.1	8.06	8.10	2.77	2.52	0.24	2.27	0.121
8:55:18 PM	26.2	26.1	8.06	8.10	2.77	2.52	0.24	2.27	0.121
8:56:18 PM	26.2	26.1	8.06	8.10	2.77	2.52	0.24	2.27	0.121
8:57:18 PM	26.2	26.1	8.06	8.10	2.77	2.52	0.24	2.27	0.121
8:58:18 PM	26.2	26.1	8.07	8.11	2.70	2.47	0.24	2.20	0.118
8:59:18 PM	26.2	26.1	8.07	8.11	2.70	2.47	0.24	2.20	0.118
9:00:18 PM	26.2	26.1	8.07	8.11	2.70	2.47	0.24	2.20	0.118
9:01:18 PM	26.2	26.1	8.07	8.11	2.70	2.47	0.24	2.20	0.118
9:02:18 PM	26.2	26.1	8.07	8.11	2.70	2.47	0.24	2.20	0.118
9:03:18 PM	26.2	26.1	8.08	8.12	2.64	2.41	0.23	2.14	0.116
9:04:18 PM	26.2	26.1	8.08	8.12	2.64	2.41	0.23	2.14	0.116
9:05:18 PM	26.2	26.1	8.08	8.12	2.64	2.41	0.23	2.14	0.116

15.2 cm air-lift_Trial 1_8/23/2008 (continued)

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		$C_t - C_{out}$	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
9:06:18 PM	26.2	26.1	8.08	8.12	2.64	2.41	0.23	2.14	0.116
9:07:18 PM	26.2	26.1	8.09	8.12	2.58	2.41	0.17	2.08	0.086
9:08:18 PM	26.2	26.1	8.09	8.13	2.58	2.36	0.23	2.08	0.113
9:09:18 PM	26.2	26.1	8.09	8.13	2.58	2.36	0.23	2.08	0.113
9:10:18 PM	26.2	26.1	8.09	8.13	2.58	2.36	0.23	2.08	0.113
9:11:18 PM	26.2	26.1	8.09	8.13	2.58	2.36	0.23	2.08	0.113
9:12:18 PM	26.2	26.1	8.09	8.14	2.58	2.30	0.28	2.08	0.140
9:13:18 PM	26.2	26.1	8.10	8.14	2.52	2.30	0.22	2.02	0.111
9:14:18 PM	26.2	26.1	8.10	8.14	2.52	2.30	0.22	2.02	0.111
9:15:18 PM	26.2	26.1	8.10	8.14	2.52	2.30	0.22	2.02	0.111
9:16:18 PM	26.2	26.1	8.10	8.14	2.52	2.30	0.22	2.02	0.111
9:17:18 PM	26.2	26.1	8.10	8.15	2.52	2.25	0.27	2.02	0.137
9:18:18 PM	26.2	26.1	8.11	8.15	2.47	2.25	0.22	1.97	0.108
9:19:18 PM	26.2	26.1	8.11	8.15	2.47	2.25	0.22	1.97	0.108
9:20:18 PM	26.2	26.1	8.11	8.15	2.47	2.25	0.22	1.97	0.108
9:21:18 PM	26.2	26.1	8.11	8.15	2.47	2.25	0.22	1.97	0.108
9:22:18 PM	26.2	26.1	8.11	8.15	2.47	2.25	0.22	1.97	0.108
9:23:18 PM	26.2	26.1	8.12	8.16	2.41	2.20	0.21	1.91	0.106
9:24:18 PM	26.2	26.1	8.12	8.16	2.41	2.20	0.21	1.91	0.106
9:25:18 PM	26.2	26.1	8.12	8.16	2.41	2.20	0.21	1.91	0.106
9:26:18 PM	26.2	26.1	8.12	8.16	2.41	2.20	0.21	1.91	0.106
9:27:18 PM	26.2	26.1	8.12	8.16	2.41	2.20	0.21	1.91	0.106
9:28:18 PM	26.2	26.1	8.12	8.16	2.41	2.20	0.21	1.91	0.106

15.2 cm air-lift_Trial 2_8/24/2008

Hydraulic and Alkalinity Summary

Time	Volume [liters]	Fill time [sec]	Q_L [l min^{-1}]	Alk [mg l^{-1}]
11:25 AM	20.06	3.56	338.09	157
11:45 AM	20.06	3.58	336.20	155
12:30 PM	20.06	3.47	346.86	154
1:50 PM	20.06	3.5	343.89	159

Lift	30.5	cm	$Q_{L,ave}$	341.26	l min^{-1}
C_s	0.5	mg l^{-1}	$Q_{G,ave}$	340.00	l min^{-1}
FW_{CO2}	44.01	g mol^{-1}	Q_G:Q_L	1.00	
V_{tank}	8066	liters	Alkalinity	156	mg $CaCO_3$ l^{-1}

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		C_t - C_{out}	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
11:17:06 AM	25.9	25.8	8.48	8.48	1.06	1.06	0.00	0.56	0.000
11:18:06 AM	25.9	25.8	8.48	8.48	1.06	1.06	0.00	0.56	0.000
11:19:06 AM	25.9	25.8	8.48	8.48	1.06	1.06	0.00	0.56	0.000
11:20:06 AM	25.9	25.8	8.22	8.35	1.93	1.43	0.50	1.43	0.245
11:21:06 AM	25.9	25.8	7.11	6.93	24.82	37.57	-12.75	24.32	-6.264
11:22:06 AM	25.9	25.8	6.82	6.68	48.40	66.81	-18.41	47.90	-9.047
11:23:06 AM	25.9	25.8	6.62	6.52	76.71	96.57	-19.86	76.21	-9.760
11:24:06 AM	25.9	25.8	6.56	6.60	88.07	80.32	7.75	87.57	3.808
11:25:06 AM	25.9	25.8	6.57	6.61	86.07	78.49	7.57	85.57	3.721
11:26:06 AM	25.9	25.8	6.57	6.62	86.07	76.71	9.36	85.57	4.599
11:27:06 AM	25.9	25.8	6.58	6.62	84.11	76.71	7.40	83.61	3.637
11:28:06 AM	25.9	25.8	6.59	6.63	82.19	74.96	7.23	81.69	3.554
11:29:06 AM	25.9	25.8	6.59	6.65	82.19	71.59	10.61	81.69	5.212
11:30:06 AM	25.9	25.8	6.60	6.65	80.32	71.59	8.73	79.82	4.292
11:31:06 AM	25.9	25.8	6.61	6.67	78.49	68.37	10.13	77.99	4.977
11:32:06 AM	25.9	25.8	6.62	6.67	76.71	68.37	8.34	76.21	4.099
11:33:06 AM	25.9	25.8	6.63	6.69	74.96	65.29	9.67	74.46	4.753
11:34:06 AM	25.9	25.8	6.64	6.69	73.25	65.29	7.97	72.75	3.915
11:35:06 AM	25.9	25.8	6.64	6.70	73.25	63.80	9.45	72.75	4.645
11:36:06 AM	25.9	25.8	6.65	6.71	71.59	62.35	9.24	71.09	4.539

15.2 cm air-lift_Trial 2_8/24/2008 (continued)

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		$C_t - C_{out}$	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
11:37:06 AM	25.9	25.8	6.66	6.72	69.96	60.93	9.03	69.46	4.436
11:38:06 AM	25.9	25.8	6.67	6.73	68.37	59.54	8.82	67.87	4.335
11:39:06 AM	25.9	25.8	6.68	6.73	66.81	59.54	7.27	66.31	3.570
11:40:06 AM	25.9	25.8	6.69	6.75	65.29	56.86	8.42	64.79	4.140
11:41:06 AM	25.9	25.8	6.70	6.76	63.80	55.57	8.23	63.30	4.046
11:42:06 AM	25.9	25.8	6.71	6.76	62.35	55.57	6.78	61.85	3.332
11:43:06 AM	25.9	25.9	6.73	6.77	59.54	54.30	5.24	59.04	2.575
11:44:06 AM	25.9	25.9	6.74	6.79	58.19	51.86	6.33	57.69	3.110
11:45:06 AM	25.9	25.9	6.74	6.79	58.19	51.86	6.33	57.69	3.110
11:46:06 AM	25.9	25.9	6.75	6.80	56.86	50.68	6.18	56.36	3.039
11:47:06 AM	25.9	25.9	6.76	6.81	55.57	49.53	6.04	55.07	2.970
11:48:06 AM	25.9	25.9	6.77	6.82	54.30	48.40	5.91	53.80	2.902
11:49:06 AM	25.9	25.9	6.78	6.83	53.07	47.30	5.77	52.57	2.836
11:50:06 AM	25.9	25.9	6.79	6.84	51.86	46.22	5.64	51.36	2.771
11:51:06 AM	25.9	25.9	6.80	6.85	50.68	45.17	5.51	50.18	2.708
11:52:06 AM	25.9	25.9	6.81	6.86	49.53	44.14	5.39	49.03	2.647
11:53:06 AM	25.9	25.9	6.82	6.86	48.40	44.14	4.26	47.90	2.093
11:54:06 AM	25.9	25.9	6.83	6.87	47.30	43.14	4.16	46.80	2.045
11:55:06 AM	25.9	25.9	6.84	6.88	46.22	42.15	4.07	45.72	1.999
11:56:06 AM	25.9	25.9	6.85	6.89	45.17	41.19	3.97	44.67	1.953
11:57:06 AM	25.9	25.9	6.85	6.90	45.17	40.26	4.91	44.67	2.414
11:58:06 AM	25.9	25.9	6.86	6.91	44.14	39.34	4.80	43.64	2.359
11:59:06 AM	25.9	25.9	6.87	6.91	43.14	39.34	3.80	42.64	1.865
12:00:06 PM	25.9	25.9	6.88	6.93	42.15	37.57	4.58	41.65	2.253
12:01:06 PM	25.9	25.9	6.89	6.94	41.19	36.71	4.48	40.69	2.201
12:02:06 PM	25.9	25.9	6.90	6.94	40.26	36.71	3.54	39.76	1.741
12:03:06 PM	25.9	25.9	6.91	6.95	39.34	35.88	3.46	38.84	1.701
12:04:06 PM	25.9	25.9	6.92	6.96	38.44	35.06	3.38	37.94	1.662
12:05:06 PM	25.9	25.9	6.93	6.97	37.57	34.26	3.31	37.07	1.624
12:06:06 PM	25.9	25.9	6.94	6.98	36.71	33.48	3.23	36.21	1.587
12:07:06 PM	25.9	25.9	6.94	6.99	36.71	32.72	3.99	36.21	1.962
12:08:06 PM	25.9	25.9	6.95	7.00	35.88	31.98	3.90	35.38	1.917
12:09:06 PM	25.9	25.9	6.96	7.00	35.06	31.98	3.09	34.56	1.516
12:10:06 PM	25.9	25.9	6.97	7.01	34.26	31.25	3.01	33.76	1.482
12:11:06 PM	25.9	25.9	6.98	7.02	33.48	30.54	2.95	32.98	1.448

15.2 cm air-lift_Trial 2_8/24/2008 (continued)

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		$C_t - C_{out}$	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
12:12:06 PM	25.9	25.9	6.99	7.03	32.72	29.84	2.88	32.22	1.415
12:13:06 PM	25.9	25.9	7.00	7.05	31.98	28.50	3.48	31.48	1.709
12:14:06 PM	25.9	25.9	7.01	7.05	31.25	28.50	2.75	30.75	1.351
12:15:06 PM	25.9	25.9	7.01	7.06	31.25	27.85	3.40	30.75	1.670
12:16:06 PM	25.9	25.9	7.02	7.07	30.54	27.22	3.32	30.04	1.632
12:17:06 PM	25.9	25.9	7.03	7.07	29.84	27.22	2.63	29.34	1.290
12:18:06 PM	25.9	25.9	7.04	7.09	29.16	25.99	3.17	28.66	1.558
12:19:06 PM	25.9	25.9	7.05	7.09	28.50	25.99	2.51	28.00	1.232
12:20:06 PM	25.9	25.9	7.06	7.10	27.85	25.40	2.45	27.35	1.204
12:21:06 PM	25.9	25.9	7.07	7.11	27.22	24.82	2.39	26.72	1.177
12:22:06 PM	25.9	25.9	7.07	7.12	27.22	24.26	2.96	26.72	1.454
12:23:06 PM	25.9	25.9	7.08	7.13	26.60	23.70	2.89	26.10	1.421
12:24:06 PM	25.9	25.9	7.09	7.14	25.99	23.17	2.83	25.49	1.389
12:25:06 PM	25.9	25.9	7.10	7.15	25.40	22.64	2.76	24.90	1.357
12:26:06 PM	25.9	25.9	7.11	7.15	24.82	22.64	2.18	24.32	1.073
12:27:06 PM	25.9	25.9	7.12	7.16	24.26	22.12	2.13	23.76	1.049
12:28:06 PM	25.9	25.9	7.13	7.17	23.70	21.62	2.09	23.20	1.025
12:29:06 PM	25.9	25.9	7.13	7.18	23.70	21.13	2.58	23.20	1.267
12:30:06 PM	25.9	25.9	7.14	7.18	23.17	21.13	2.04	22.67	1.002
12:31:06 PM	25.9	25.9	7.15	7.20	22.64	20.18	2.46	22.14	1.210
12:32:06 PM	25.9	25.9	7.16	7.21	22.12	19.72	2.41	21.62	1.182
12:33:06 PM	25.9	25.9	7.17	7.21	21.62	19.72	1.90	21.12	0.935
12:34:06 PM	25.9	25.9	7.18	7.22	21.13	19.27	1.86	20.63	0.914
12:35:06 PM	25.9	25.9	7.19	7.23	20.65	18.83	1.82	20.15	0.893
12:36:06 PM	25.9	25.9	7.20	7.24	20.18	18.40	1.78	19.68	0.872
12:37:06 PM	25.9	25.9	7.20	7.24	20.18	18.40	1.78	19.68	0.872
12:38:06 PM	25.9	25.9	7.21	7.26	19.72	17.57	2.14	19.22	1.054
12:39:06 PM	25.9	25.9	7.22	7.26	19.27	17.57	1.70	18.77	0.833
12:40:06 PM	25.9	25.9	7.23	7.27	18.83	17.17	1.66	18.33	0.814
12:41:06 PM	25.9	25.9	7.24	7.28	18.40	16.78	1.62	17.90	0.796
12:42:06 PM	25.9	25.9	7.25	7.28	17.98	16.78	1.20	17.48	0.590
12:43:06 PM	25.9	25.9	7.25	7.29	17.98	16.40	1.58	17.48	0.778
12:44:06 PM	25.9	25.9	7.26	7.30	17.57	16.03	1.55	17.07	0.760
12:45:06 PM	25.9	25.9	7.27	7.30	17.17	16.03	1.15	16.67	0.563
12:46:06 PM	26	25.9	7.28	7.32	16.78	15.31	1.48	16.28	0.726

15.2 cm air-lift_Trial 2_8/24/2008 (continued)

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		$C_t - C_{out}$	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
12:47:06 PM	26	25.9	7.29	7.33	16.40	14.96	1.44	15.90	0.709
12:48:06 PM	26	25.9	7.29	7.34	16.40	14.62	1.78	15.90	0.876
12:49:06 PM	26	25.9	7.30	7.34	16.03	14.62	1.41	15.53	0.693
12:50:06 PM	26	25.9	7.31	7.35	15.66	14.28	1.38	15.16	0.677
12:51:06 PM	26	25.9	7.32	7.36	15.31	13.96	1.35	14.81	0.662
12:52:06 PM	26	25.9	7.33	7.36	14.96	13.96	1.00	14.46	0.491
12:53:06 PM	26	25.9	7.34	7.38	14.62	13.33	1.29	14.12	0.632
12:54:06 PM	26	25.9	7.34	7.38	14.62	13.33	1.29	14.12	0.632
12:55:06 PM	26	25.9	7.35	7.39	14.28	13.03	1.26	13.78	0.618
12:56:06 PM	26	25.9	7.36	7.39	13.96	13.03	0.93	13.46	0.458
12:57:06 PM	26	25.9	7.37	7.40	13.64	12.73	0.91	13.14	0.447
12:58:06 PM	26	25.9	7.37	7.40	13.64	12.73	0.91	13.14	0.447
12:59:06 PM	26	25.9	7.38	7.42	13.33	12.16	1.17	12.83	0.576
1:00:06 PM	26	25.9	7.39	7.43	13.03	11.88	1.15	12.53	0.563
1:01:06 PM	26	25.9	7.40	7.43	12.73	11.88	0.85	12.23	0.418
1:02:06 PM	26	25.9	7.41	7.44	12.44	11.61	0.83	11.94	0.408
1:03:06 PM	26	25.9	7.41	7.45	12.44	11.35	1.09	11.94	0.538
1:04:06 PM	26	25.9	7.42	7.46	12.16	11.09	1.07	11.66	0.526
1:05:06 PM	26	25.9	7.43	7.46	11.88	11.09	0.79	11.38	0.390
1:06:06 PM	26	25.9	7.44	7.47	11.61	10.84	0.77	11.11	0.381
1:07:06 PM	26	25.9	7.45	7.48	11.35	10.59	0.76	10.85	0.372
1:08:06 PM	26	25.9	7.45	7.48	11.35	10.59	0.76	10.85	0.372
1:09:06 PM	26	25.9	7.46	7.49	11.09	10.35	0.74	10.59	0.364
1:10:06 PM	26	25.9	7.47	7.50	10.84	10.11	0.72	10.34	0.355
1:11:06 PM	26	25.9	7.47	7.50	10.84	10.11	0.72	10.34	0.355
1:12:06 PM	26	25.9	7.48	7.51	10.59	9.88	0.71	10.09	0.347
1:13:06 PM	26	25.9	7.49	7.52	10.35	9.66	0.69	9.85	0.339
1:14:06 PM	26	25.9	7.50	7.53	10.11	9.44	0.67	9.61	0.332
1:15:06 PM	26	25.9	7.50	7.53	10.11	9.44	0.67	9.61	0.332
1:16:06 PM	26	25.9	7.51	7.54	9.88	9.22	0.66	9.38	0.324
1:17:06 PM	26	25.9	7.52	7.55	9.66	9.01	0.64	9.16	0.317
1:18:06 PM	26	25.9	7.53	7.55	9.44	9.01	0.42	8.94	0.209
1:19:06 PM	26	25.9	7.53	7.56	9.44	8.81	0.63	8.94	0.310
1:20:06 PM	26	25.9	7.54	7.57	9.22	8.61	0.62	8.72	0.302
1:21:06 PM	26	25.9	7.55	7.57	9.01	8.61	0.41	8.51	0.199

15.2 cm air-lift_Trial 2_8/24/2008 (continued)

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		$C_t - C_{out}$	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
1:22:06 PM	26	25.9	7.56	7.58	8.81	8.41	0.40	8.31	0.195
1:23:06 PM	26	25.9	7.56	7.59	8.81	8.22	0.59	8.31	0.289
1:24:06 PM	26	25.9	7.57	7.59	8.61	8.22	0.39	8.11	0.190
1:25:06 PM	26	25.9	7.57	7.60	8.61	8.03	0.57	8.11	0.282
1:26:06 PM	26	25.9	7.58	7.61	8.41	7.85	0.56	7.91	0.276
1:27:06 PM	26	25.9	7.59	7.61	8.22	7.85	0.37	7.72	0.182
1:28:06 PM	26	26	7.60	7.62	8.03	7.67	0.36	7.53	0.178
1:29:06 PM	26	26	7.60	7.63	8.03	7.50	0.54	7.53	0.263
1:30:06 PM	26	26	7.61	7.63	7.85	7.50	0.35	7.35	0.174

15.2 cm air-lift_Trial 3_8/24/2008

Hydraulic and Alkalinity Summary

Time	Volume [liters]	Fill time [sec]	Q_L [l min^{-1}]	Alk [mg l^{-1}]
2:10 PM	20.06	3.48	345.86	156
2:45 PM	20.06	3.57	337.14	155
3:30 PM	20.06	3.42	351.93	153
4:00 PM	20.06	3.59	335.26	158

Lift	30.5	cm	$Q_{L,ave}$	342.55	l min^{-1}
C_s	0.5	mg l^{-1}	$Q_{G,ave}$	340.00	l min^{-1}
FW_{CO2}	44.01	g mol^{-1}	Q_G:Q_L	0.99	
V_{tank}	8066	liters	Alkalinity	156	mg $CaCO_3$ l^{-1}

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		$C_t - C_{out}$	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
2:08:38 PM	26.1	26.0	7.77	7.77	5.40	5.40	0.00	4.90	0.000
2:08:48 PM	26.0	26.0	7.77	7.77	5.40	5.40	0.00	4.90	0.000
2:08:58 PM	26.1	26.0	7.77	7.77	5.40	5.40	0.00	4.90	0.000
2:09:09 PM	26.0	26.0	7.77	7.57	5.40	8.57	-3.16	4.90	-1.559
2:09:18 PM	26.0	26.0	7.77	7.10	5.40	25.28	-19.87	4.90	-9.803

15.2 cm air-lift_Trial 3_8/24/2008 (continued)

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		$C_t - C_{out}$	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
2:09:28 PM	26.0	26.0	7.69	7.16	6.50	22.02	-15.52	6.00	-7.655
2:09:38 PM	26.0	26.0	7.55	7.17	8.97	21.52	-12.55	8.47	-6.189
2:09:49 PM	26.0	26.0	7.39	7.18	12.96	21.03	-8.06	12.46	-3.976
2:09:58 PM	26.0	26.0	7.21	7.11	19.62	24.70	-5.08	19.12	-2.506
2:10:08 PM	26.0	26.0	7.09	7.04	25.87	29.02	-3.16	25.37	-1.557
2:10:18 PM	26.0	26.0	6.99	7.03	32.56	29.70	2.87	32.06	1.413
2:10:29 PM	26.0	26.0	6.94	7.04	36.54	29.02	7.51	36.04	3.707
2:10:38 PM	26.0	26.0	6.89	6.92	41.00	38.26	2.74	40.50	1.350
2:10:48 PM	26.0	26.0	6.87	6.88	42.93	41.95	0.98	42.43	0.482
2:10:58 PM	26.0	26.0	6.83	6.84	47.07	46.00	1.07	46.57	0.529
2:11:08 PM	26.0	26.0	6.76	6.79	55.30	51.61	3.69	54.80	1.821
2:11:18 PM	26.0	26.0	6.72	6.80	60.64	50.44	10.20	60.14	5.032
2:11:36 PM	26.0	26.0	6.69	6.69	64.97	64.97	0.00	64.47	0.000
2:12:36 PM	26.0	26.0	6.67	6.71	68.04	62.05	5.99	67.54	2.953
2:13:36 PM	26.0	26.0	6.67	6.72	68.04	60.64	7.40	67.54	3.650
2:14:36 PM	26.0	26.0	6.68	6.72	66.49	60.64	5.85	65.99	2.886
2:15:36 PM	26.0	26.0	6.68	6.73	66.49	59.26	7.23	65.99	3.567
2:16:36 PM	26.0	26.0	6.69	6.74	64.97	57.91	7.07	64.47	3.485
2:17:36 PM	26.0	26.0	6.70	6.75	63.50	56.59	6.91	63.00	3.406
2:18:36 PM	26.0	26.0	6.71	6.76	62.05	55.30	6.75	61.55	3.329
2:19:36 PM	26.1	26.0	6.72	6.75	60.64	56.59	4.05	60.14	1.996
2:20:36 PM	26.1	26.0	6.72	6.77	60.64	54.04	6.59	60.14	3.253
2:21:36 PM	26.1	26.0	6.73	6.79	59.26	51.61	7.65	58.76	3.772
2:22:36 PM	26.1	26.0	6.74	6.80	57.91	50.44	7.47	57.41	3.686
2:23:36 PM	26.1	26.0	6.75	6.79	56.59	51.61	4.98	56.09	2.456
2:24:36 PM	26.1	26.0	6.76	6.81	55.30	49.29	6.01	54.80	2.967
2:25:36 PM	26.1	26.0	6.77	6.83	54.04	47.07	6.97	53.54	3.440
2:26:36 PM	26.1	26.0	6.77	6.83	54.04	47.07	6.97	53.54	3.440
2:27:36 PM	26.1	26.0	6.78	6.83	52.81	47.07	5.74	52.31	2.833
2:28:36 PM	26.1	26.0	6.79	6.85	51.61	44.95	6.66	51.11	3.285
2:29:36 PM	26.1	26.0	6.80	6.85	50.44	44.95	5.48	49.94	2.706
2:30:36 PM	26.1	26.0	6.80	6.87	50.44	42.93	7.51	49.94	3.704
2:31:36 PM	26.1	26.0	6.81	6.87	49.29	42.93	6.36	48.79	3.137
2:32:36 PM	26.1	26.0	6.82	6.88	48.17	41.95	6.22	47.67	3.066
2:33:36 PM	26.1	26.0	6.83	6.89	47.07	41.00	6.07	46.57	2.996

15.2 cm air-lift_Trial 3_8/24/2008 (continued)

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		$C_t - C_{out}$	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
2:34:36 PM	26.1	26.0	6.84	6.90	46.00	40.06	5.94	45.50	2.928
2:35:36 PM	26.1	26.0	6.85	6.91	44.95	39.15	5.80	44.45	2.861
2:36:36 PM	26.1	26.0	6.86	6.92	43.93	38.26	5.67	43.43	2.796
2:37:36 PM	26.1	26.0	6.87	6.93	42.93	37.39	5.54	42.43	2.732
2:38:36 PM	26.1	26.0	6.88	6.93	41.95	37.39	4.56	41.45	2.250
2:39:36 PM	26.1	26.0	6.88	6.94	41.95	36.54	5.41	41.45	2.670
2:40:36 PM	26.1	26.0	6.89	6.95	41.00	35.71	5.29	40.50	2.609
2:41:36 PM	26.1	26.0	6.90	6.96	40.06	34.89	5.17	39.56	2.550
2:42:36 PM	26.1	26.0	6.91	6.97	39.15	34.10	5.05	38.65	2.492
2:43:36 PM	26.1	26.0	6.92	6.98	38.26	33.32	4.94	37.76	2.435
2:44:36 PM	26.1	26.0	6.93	6.99	37.39	32.56	4.82	36.89	2.380
2:45:36 PM	26.1	26.0	6.93	6.99	37.39	32.56	4.82	36.89	2.380
2:46:36 PM	26.1	26.0	6.95	7.01	35.71	31.10	4.61	35.21	2.273
2:47:36 PM	26.1	26.0	6.95	7.01	35.71	31.10	4.61	35.21	2.273
2:48:36 PM	26.1	26.0	6.96	7.02	34.89	30.39	4.50	34.39	2.221
2:49:36 PM	26.1	26.0	6.97	7.03	34.10	29.70	4.40	33.60	2.170
2:50:36 PM	26.1	26.0	6.98	7.04	33.32	29.02	4.30	32.82	2.121
2:51:36 PM	26.1	26.0	6.99	7.05	32.56	28.36	4.20	32.06	2.073
2:52:36 PM	26.1	26.0	7.00	7.06	31.82	27.72	4.11	31.32	2.026
2:53:36 PM	26.1	26.0	7.01	7.06	31.10	27.72	3.38	30.60	1.668
2:54:36 PM	26.1	26.0	7.02	7.07	30.39	27.09	3.30	29.89	1.630
2:55:36 PM	26.1	26.0	7.02	7.08	30.39	26.47	3.92	29.89	1.934
2:56:36 PM	26.1	26.0	7.04	7.09	29.02	25.87	3.16	28.52	1.557
2:57:36 PM	26.1	26.0	7.04	7.10	29.02	25.28	3.75	28.52	1.847
2:58:36 PM	26.1	26.0	7.05	7.11	28.36	24.70	3.66	27.86	1.805
2:59:36 PM	26.1	26.0	7.06	7.12	27.72	24.14	3.58	27.22	1.764
3:00:36 PM	26.1	26.0	7.07	7.13	27.09	23.59	3.50	26.59	1.724
3:01:36 PM	26.1	26.0	7.07	7.13	27.09	23.59	3.50	26.59	1.724
3:02:36 PM	26.1	26.0	7.09	7.14	25.87	23.05	2.81	25.37	1.388
3:03:36 PM	26.1	26.0	7.09	7.16	25.87	22.02	3.85	25.37	1.899
3:04:36 PM	26.1	26.0	7.10	7.16	25.28	22.02	3.26	24.78	1.609
3:05:36 PM	26.1	26.0	7.11	7.17	24.70	21.52	3.19	24.20	1.572
3:06:36 PM	26.1	26.0	7.12	7.17	24.14	21.52	2.63	23.64	1.295
3:07:36 PM	26.1	26.0	7.13	7.18	23.59	21.03	2.57	23.09	1.265
3:08:36 PM	26.1	26.0	7.14	7.19	23.05	20.55	2.51	22.55	1.237

15.2 cm air-lift_Trial 3_8/24/2008 (continued)

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		$C_t - C_{out}$	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
3:09:36 PM	26.1	26.0	7.14	7.20	23.05	20.08	2.97	22.55	1.467
3:10:36 PM	26.1	26.0	7.15	7.20	22.53	20.08	2.45	22.03	1.209
3:11:36 PM	26.1	26.0	7.16	7.22	22.02	19.18	2.84	21.52	1.401
3:12:36 PM	26.1	26.0	7.17	7.22	21.52	19.18	2.34	21.02	1.154
3:13:36 PM	26.1	26.0	7.17	7.23	21.52	18.74	2.78	21.02	1.369
3:14:36 PM	26.1	26.0	7.18	7.24	21.03	18.31	2.71	20.53	1.338
3:15:36 PM	26.1	26.0	7.19	7.25	20.55	17.90	2.65	20.05	1.308
3:16:36 PM	26.1	26.0	7.20	7.26	20.08	17.49	2.59	19.58	1.278
3:17:36 PM	26.1	26.0	7.21	7.26	19.62	17.49	2.13	19.12	1.053
3:18:36 PM	26.1	26.0	7.22	7.27	19.18	17.09	2.09	18.68	1.029
3:19:36 PM	26.1	26.0	7.22	7.28	19.18	16.70	2.47	18.68	1.221
3:20:36 PM	26.1	26.0	7.23	7.29	18.74	16.32	2.42	18.24	1.193
3:21:36 PM	26.1	26.0	7.24	7.29	18.31	16.32	1.99	17.81	0.982
3:22:36 PM	26.1	26.0	7.25	7.30	17.90	15.95	1.95	17.40	0.960
3:23:36 PM	26.1	26.0	7.26	7.31	17.49	15.59	1.90	16.99	0.938
3:24:36 PM	26.1	26.0	7.27	7.32	17.09	15.23	1.86	16.59	0.917
3:25:36 PM	26.1	26.0	7.27	7.33	17.09	14.88	2.21	16.59	1.088
3:26:36 PM	26.1	26.0	7.28	7.34	16.70	14.55	2.16	16.20	1.063
3:27:36 PM	26.1	26.1	7.29	7.34	16.32	14.55	1.77	15.82	0.876
3:28:36 PM	26.1	26.1	7.30	7.35	15.95	14.21	1.73	15.45	0.856
3:29:36 PM	26.1	26.1	7.30	7.36	15.95	13.89	2.06	15.45	1.015
3:30:36 PM	26.1	26.1	7.31	7.36	15.59	13.89	1.70	15.09	0.836
3:31:36 PM	26.1	26.1	7.32	7.38	15.23	13.27	1.97	14.73	0.969
3:32:36 PM	26.1	26.1	7.33	7.38	14.88	13.27	1.62	14.38	0.798
3:33:36 PM	26.1	26.1	7.34	7.39	14.55	12.96	1.58	14.05	0.780
3:34:36 PM	26.1	26.1	7.35	7.40	14.21	12.67	1.55	13.71	0.763
3:35:36 PM	26.1	26.1	7.35	7.40	14.21	12.67	1.55	13.71	0.763
3:36:36 PM	26.1	26.1	7.36	7.41	13.89	12.38	1.51	13.39	0.745
3:37:36 PM	26.1	26.1	7.37	7.42	13.58	12.10	1.48	13.08	0.728
3:38:36 PM	26.1	26.1	7.37	7.43	13.58	11.82	1.75	13.08	0.864
3:39:36 PM	26.1	26.1	7.38	7.44	13.27	11.55	1.71	12.77	0.844
3:40:36 PM	26.1	26.1	7.39	7.44	12.96	11.55	1.41	12.46	0.695
3:41:36 PM	26.1	26.1	7.40	7.45	12.67	11.29	1.38	12.17	0.680
3:42:36 PM	26.1	26.1	7.40	7.46	12.67	11.03	1.63	12.17	0.806
3:43:36 PM	26.1	26.1	7.41	7.46	12.38	11.03	1.35	11.88	0.664

15.2 cm air-lift_Trial 3_8/24/2008 (continued)

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		$C_t - C_{out}$	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
3:44:36 PM	26.1	26.1	7.42	7.47	12.10	10.78	1.32	11.60	0.649
3:45:36 PM	26.1	26.1	7.43	7.48	11.82	10.54	1.29	11.32	0.634
3:46:36 PM	26.1	26.1	7.44	7.49	11.55	10.30	1.26	11.05	0.620
3:47:36 PM	26.1	26.1	7.44	7.49	11.55	10.30	1.26	11.05	0.620
3:48:36 PM	26.1	26.1	7.45	7.50	11.29	10.06	1.23	10.79	0.606
3:49:36 PM	26.1	26.1	7.46	7.50	11.03	10.06	0.97	10.53	0.479
3:50:36 PM	26.1	26.1	7.47	7.51	10.78	9.83	0.95	10.28	0.468
3:51:36 PM	26.1	26.1	7.47	7.52	10.78	9.61	1.17	10.28	0.578
3:52:36 PM	26.1	26.1	7.48	7.52	10.54	9.61	0.93	10.04	0.457
3:53:36 PM	26.1	26.1	7.49	7.53	10.30	9.39	0.91	9.80	0.447
3:54:36 PM	26.1	26.1	7.49	7.54	10.30	9.18	1.12	9.80	0.552
3:55:36 PM	26.1	26.1	7.50	7.55	10.06	8.97	1.09	9.56	0.540
3:56:36 PM	26.1	26.1	7.51	7.55	9.83	8.97	0.87	9.33	0.427

pH/Alkalinity CTR and $C_{deficit}$ Linear Regression Summary for 340 l min^{-1} air injection

Air-lift [cm]	Trial	Lift [cm]	CTR Coefficient for $C_{deficit}$ equations	R^2
15.2	1	30.5	$CTR = 0.0709*C_{deficit}$	0.984
15.2	2	30.5	$CTR = 0.0540*C_{deficit}$	0.947
15.2	3	30.5	$CTR = 0.0624*C_{deficit}$	0.976

pH/Alkalinity K_La and SCTR Summary for 340 l min^{-1} air injection

		K_La [min^{-1}]		K_La_{20} [min^{-1}]		SCTR [kg hr^{-1}]	
Air-lift [cm]	Trial	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet
15.2	1	0.021	0.020	0.018	0.017	0.0043	0.0041
15.2	2	0.020	0.019	0.017	0.017	0.0041	0.0040
15.2	3	0.020	0.020	0.017	0.017	0.0041	0.0041
	Ave	**0.020**	**0.020**	**0.017**	**0.017**	**0.0042**	**0.0041**
	St. D.	**0.000**	**0.000**	**0.000**	**0.000**	**0.0001**	**0.0001**

DEGASSING STUDIES_pH/Alkalinity Method (continued)

15.2 cm air-lift_495 l air min^{-1}

15.2 cm air-lift_Trial 1_8/25/2008

Hydraulic and Alkalinity Summary

Time	Volume [liters]	Fill time [sec]	Q_L [l min^{-1}]	Alk [mg l^{-1}]
10:00 AM	20.06	3.60	334.33	158
10:15 AM	20.06	3.62	332.49	155
10:45 AM	20.06	3.48	345.86	156
11:30 AM	20.06	3.51	342.91	160

Lift	38.1	cm	$Q_{L,ave}$	338.90	l min^{-1}
C_s	0.5	mg l^{-1}	$Q_{G,ave}$	495.00	l min^{-1}
FW_{CO2}	44.01	g mol^{-1}	Q_G:Q_L	1.46	
V_{tank}	7973.3	liters	Alkalinity	157	mg $CaCO_3$ l^{-1}

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		C_t - C_{out}	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
9:58:04 AM	26.1	26.0	7.89	7.90	4.15	4.05	0.09	3.65	0.046
9:58:14 AM	26.1	26.0	7.89	7.88	4.15	4.24	-0.10	3.65	-0.047
9:58:25 AM	26.1	26.0	7.89	7.56	4.15	8.86	-4.72	3.65	-2.302
9:58:34 AM	26.1	26.0	7.88	7.25	4.24	18.10	-13.85	3.74	-6.761
9:58:44 AM	26.1	26.0	7.56	7.53	8.86	9.50	-0.63	8.36	-0.309
9:58:54 AM	26.1	26.0	7.19	7.33	20.78	15.05	5.73	20.28	2.794
9:59:05 AM	26.1	26.0	7.15	7.13	22.78	23.86	-1.07	22.28	-0.524
9:59:14 AM	26.1	26.0	7.11	7.10	24.98	25.56	-0.58	24.48	-0.284
9:59:24 AM	26.1	26.0	7.04	6.92	29.35	38.69	-9.34	28.85	-4.558
9:59:34 AM	26.1	26.0	6.95	6.86	36.11	44.42	-8.31	35.61	-4.058
9:59:45 AM	26.1	26.0	6.90	6.85	40.51	45.46	-4.94	40.01	-2.412
9:59:54 AM	26.1	26.0	6.89	6.79	41.46	52.19	-10.73	40.96	-5.239
10:00:04 AM	26.1	26.0	6.80	6.78	51.00	53.41	-2.40	50.50	-1.173
10:00:14 AM	26.1	26.1	6.77	6.83	54.65	47.60	7.05	54.15	3.441
10:00:24 AM	26.1	26.0	6.77	6.82	54.65	48.71	5.94	54.15	2.900
10:00:34 AM	26.1	26.0	6.79	6.81	52.19	49.84	2.35	51.69	1.146
10:00:44 AM	26.1	26.0	6.79	6.82	52.19	48.71	3.48	51.69	1.700

15.2 cm air-lift_Trial 1_8/25/2008 (continued)

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		C_t - C_{out}	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
10:00:55 AM	26.1	26.0	6.78	6.81	53.41	49.84	3.56	52.91	1.740
10:01:04 AM	26.1	26.0	6.78	6.82	53.41	48.71	4.70	52.91	2.293
10:01:14 AM	26.1	26.0	6.78	6.83	53.41	47.60	5.81	52.91	2.834
10:01:24 AM	26.1	26.0	6.78	6.83	53.41	47.60	5.81	52.91	2.834
10:01:34 AM	26.1	26.0	6.78	6.82	53.41	48.71	4.70	52.91	2.293
10:01:44 AM	26.1	26.0	6.78	6.82	53.41	48.71	4.70	52.91	2.293
10:01:54 AM	26.1	26.1	6.78	6.82	53.41	48.71	4.70	52.91	2.293
10:02:05 AM	26.1	26.0	6.79	6.83	52.19	47.60	4.59	51.69	2.241
10:02:14 AM	26.1	26.0	6.79	6.83	52.19	47.60	4.59	51.69	2.241
10:02:24 AM	26.1	26.0	6.79	6.83	52.19	47.60	4.59	51.69	2.241
10:02:35 AM	26.1	26.1	6.79	6.82	52.19	48.71	3.48	51.69	1.700
10:02:44 AM	26.1	26.1	6.79	6.83	52.19	47.60	4.59	51.69	2.241
10:02:54 AM	26.1	26.0	6.79	6.83	52.19	47.60	4.59	51.69	2.241
10:03:05 AM	26.1	26.0	6.79	6.84	52.19	46.52	5.68	51.69	2.770
10:03:14 AM	26.1	26.1	6.79	6.83	52.19	47.60	4.59	51.69	2.241
10:03:24 AM	26.1	26.1	6.79	6.84	52.19	46.52	5.68	51.69	2.770
10:03:35 AM	26.1	26.1	6.80	6.85	51.00	45.46	5.55	50.50	2.707
10:03:44 AM	26.1	26.1	6.80	6.84	51.00	46.52	4.49	50.50	2.190
10:03:54 AM	26.1	26.1	6.80	6.85	51.00	45.46	5.55	50.50	2.707
10:04:05 AM	26.1	26.1	6.80	6.85	51.00	45.46	5.55	50.50	2.707
10:04:14 AM	26.1	26.1	6.80	6.84	51.00	46.52	4.49	50.50	2.190
10:04:25 AM	26.1	26.1	6.80	6.84	51.00	46.52	4.49	50.50	2.190
10:04:34 AM	26.1	26.1	6.81	6.85	49.84	45.46	4.39	49.34	2.140
10:04:44 AM	26.1	26.1	6.81	6.85	49.84	45.46	4.39	49.34	2.140
10:04:55 AM	26.1	26.1	6.81	6.85	49.84	45.46	4.39	49.34	2.140
10:05:04 AM	26.1	26.1	6.81	6.86	49.84	44.42	5.42	49.34	2.645
10:05:14 AM	26.1	26.1	6.81	6.85	49.84	45.46	4.39	49.34	2.140
10:05:24 AM	26.1	26.1	6.81	6.85	49.84	45.46	4.39	49.34	2.140
10:05:34 AM	26.1	26.1	6.82	6.86	48.71	44.42	4.29	48.21	2.092
10:05:45 AM	26.1	26.1	6.82	6.87	48.71	43.41	5.30	48.21	2.585
10:05:54 AM	26.1	26.1	6.82	6.87	48.71	43.41	5.30	48.21	2.585
10:06:04 AM	26.1	26.1	6.82	6.87	48.71	43.41	5.30	48.21	2.585
10:06:14 AM	26.1	26.1	6.82	6.87	48.71	43.41	5.30	48.21	2.585
10:06:25 AM	26.1	26.1	6.83	6.87	47.60	43.41	4.19	47.10	2.044
10:06:34 AM	26.1	26.1	6.83	6.88	47.60	42.42	5.18	47.10	2.526

15.2 cm air-lift_Trial 1_8/25/2008 (continued)

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		$C_t - C_{out}$	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
10:06:44 AM	26.1	26.1	6.83	6.88	47.60	42.42	5.18	47.10	2.526
10:06:54 AM	26.1	26.1	6.83	6.88	47.60	42.42	5.18	47.10	2.526
10:07:04 AM	26.1	26.1	6.83	6.88	47.60	42.42	5.18	47.10	2.526
10:07:15 AM	26.1	26.1	6.83	6.88	47.60	42.42	5.18	47.10	2.526
10:07:24 AM	26.1	26.1	6.83	6.88	47.60	42.42	5.18	47.10	2.526
10:07:34 AM	26.1	26.1	6.83	6.88	47.60	42.42	5.18	47.10	2.526
10:07:44 AM	26.1	26.1	6.84	6.89	46.52	41.46	5.06	46.02	2.469
10:07:55 AM	26.1	26.1	6.84	6.89	46.52	41.46	5.06	46.02	2.469
10:08:04 AM	26.1	26.1	6.84	6.89	46.52	41.46	5.06	46.02	2.469
10:08:14 AM	26.1	26.1	6.84	6.89	46.52	41.46	5.06	46.02	2.469
10:08:24 AM	26.1	26.1	6.84	6.90	46.52	40.51	6.00	46.02	2.929
10:08:34 AM	26.1	26.1	6.84	6.89	46.52	41.46	5.06	46.02	2.469
10:08:44 AM	26.1	26.1	6.85	6.89	45.46	41.46	4.00	44.96	1.952
10:08:54 AM	26.1	26.1	6.85	6.89	45.46	41.46	4.00	44.96	1.952
10:09:04 AM	26.1	26.1	6.85	6.89	45.46	41.46	4.00	44.96	1.952
10:09:14 AM	26.1	26.1	6.85	6.90	45.46	40.51	4.94	44.96	2.412
10:09:24 AM	26.1	26.1	6.85	6.90	45.46	40.51	4.94	44.96	2.412
10:09:34 AM	26.1	26.1	6.85	6.89	45.46	41.46	4.00	44.96	1.952
10:09:44 AM	26.1	26.1	6.86	6.90	44.42	40.51	3.91	43.92	1.907
10:09:55 AM	26.1	26.1	6.86	6.90	44.42	40.51	3.91	43.92	1.907
10:10:04 AM	26.1	26.1	6.86	6.90	44.42	40.51	3.91	43.92	1.907
10:10:14 AM	26.1	26.1	6.86	6.91	44.42	39.59	4.83	43.92	2.358
10:10:24 AM	26.1	26.1	6.86	6.92	44.42	38.69	5.73	43.92	2.797
10:10:35 AM	26.1	26.1	6.86	6.91	44.42	39.59	4.83	43.92	2.358
10:10:44 AM	26.1	26.1	6.86	6.91	44.42	39.59	4.83	43.92	2.358
10:10:54 AM	26.1	26.1	6.86	6.91	44.42	39.59	4.83	43.92	2.358
10:11:04 AM	26.1	26.1	6.87	6.91	43.41	39.59	3.82	42.91	1.864
10:11:14 AM	26.1	26.1	6.87	6.91	43.41	39.59	3.82	42.91	1.864
10:11:24 AM	26.1	26.1	6.87	6.92	43.41	38.69	4.72	42.91	2.304
10:11:34 AM	26.1	26.1	6.87	6.92	43.41	38.69	4.72	42.91	2.304
10:11:45 AM	26.1	26.1	6.87	6.92	43.41	38.69	4.72	42.91	2.304
10:11:54 AM	26.1	26.1	6.87	6.92	43.41	38.69	4.72	42.91	2.304
10:12:04 AM	26.1	26.1	6.88	6.92	42.42	38.69	3.73	41.92	1.822
10:12:15 AM	26.1	26.1	6.88	6.92	42.42	38.69	3.73	41.92	1.822
10:12:24 AM	26.1	26.1	6.88	6.93	42.42	37.81	4.61	41.92	2.251

15.2 cm air-lift_Trial 1_8/25/2008 (continued)

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		$C_t - C_{out}$	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
10:12:34 AM	26.1	26.1	6.88	6.93	42.42	37.81	4.61	41.92	2.251
10:12:44 AM	26.1	26.1	6.88	6.93	42.42	37.81	4.61	41.92	2.251
10:12:54 AM	26.1	26.1	6.88	6.94	42.42	36.95	5.47	41.92	2.671
10:13:04 AM	26.1	26.1	6.89	6.93	41.46	37.81	3.65	40.96	1.780
10:13:14 AM	26.1	26.1	6.88	6.94	42.42	36.95	5.47	41.92	2.671
10:13:24 AM	26.1	26.1	6.89	6.95	41.46	36.11	5.35	40.96	2.611
10:13:34 AM	26.1	26.1	6.89	6.94	41.46	36.95	4.51	40.96	2.200
10:13:45 AM	26.1	26.1	6.89	6.95	41.46	36.11	5.35	40.96	2.611
10:13:54 AM	26.1	26.1	6.89	6.95	41.46	36.11	5.35	40.96	2.611
10:14:04 AM	26.1	26.1	6.89	6.95	41.46	36.11	5.35	40.96	2.611
10:14:15 AM	26.1	26.1	6.90	6.95	40.51	36.11	4.41	40.01	2.150
10:14:24 AM	26.1	26.1	6.90	6.95	40.51	36.11	4.41	40.01	2.150
10:14:34 AM	26.1	26.1	6.90	6.95	40.51	36.11	4.41	40.01	2.150
10:14:45 AM	26.1	26.1	6.90	6.95	40.51	36.11	4.41	40.01	2.150
10:14:54 AM	26.1	26.1	6.90	6.95	40.51	36.11	4.41	40.01	2.150
10:15:04 AM	26.1	26.1	6.90	6.95	40.51	36.11	4.41	40.01	2.150
10:15:14 AM	26.1	26.1	6.91	6.96	39.59	35.29	4.31	39.09	2.101
10:15:24 AM	26.1	26.1	6.91	6.96	39.59	35.29	4.31	39.09	2.101
10:15:35 AM	26.1	26.1	6.91	6.96	39.59	35.29	4.31	39.09	2.101
10:15:44 AM	26.1	26.1	6.91	6.96	39.59	35.29	4.31	39.09	2.101
10:15:54 AM	26.1	26.1	6.92	6.97	38.69	34.48	4.21	38.19	2.053
10:16:04 AM	26.1	26.1	6.92	6.96	38.69	35.29	3.40	38.19	1.661
10:16:14 AM	26.1	26.1	6.92	6.96	38.69	35.29	3.40	38.19	1.661
10:16:25 AM	26.1	26.1	6.92	6.97	38.69	34.48	4.21	38.19	2.053
10:16:34 AM	26.1	26.1	6.92	6.97	38.69	34.48	4.21	38.19	2.053
10:16:45 AM	26.1	26.1	6.92	6.98	38.69	33.70	4.99	38.19	2.436
10:16:54 AM	26.1	26.1	6.92	6.98	38.69	33.70	4.99	38.19	2.436
10:17:04 AM	26.1	26.1	6.92	6.98	38.69	33.70	4.99	38.19	2.436
10:17:14 AM	26.1	26.1	6.93	6.97	37.81	34.48	3.33	37.31	1.624
10:17:24 AM	26.1	26.1	6.93	6.98	37.81	33.70	4.11	37.31	2.007
10:17:35 AM	26.1	26.1	6.93	6.97	37.81	34.48	3.33	37.31	1.624
10:17:44 AM	26.1	26.1	6.93	6.98	37.81	33.70	4.11	37.31	2.007
10:17:55 AM	26.1	26.1	6.93	6.98	37.81	33.70	4.11	37.31	2.007
10:18:04 AM	26.1	26.1	6.93	6.98	37.81	33.70	4.11	37.31	2.007
10:18:15 AM	26.1	26.1	6.94	6.99	36.95	32.93	4.02	36.45	1.961

15.2 cm air-lift_Trial 1_8/25/2008 (continued)

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		$C_t - C_{out}$	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
10:18:24 AM	26.1	26.1	6.94	6.99	36.95	32.93	4.02	36.45	1.961
10:18:35 AM	26.1	26.1	6.94	6.99	36.95	32.93	4.02	36.45	1.961
10:18:44 AM	26.1	26.1	6.94	7.00	36.95	32.18	4.77	36.45	2.327
10:18:55 AM	26.1	26.1	6.94	6.99	36.95	32.93	4.02	36.45	1.961
10:19:04 AM	26.1	26.1	6.95	6.99	36.11	32.93	3.18	35.61	1.550
10:19:15 AM	26.1	26.1	6.95	7.00	36.11	32.18	3.93	35.61	1.916
10:19:24 AM	26.1	26.1	6.95	7.00	36.11	32.18	3.93	35.61	1.916
10:19:34 AM	26.1	26.1	6.95	7.00	36.11	32.18	3.93	35.61	1.916
10:19:45 AM	26.1	26.1	6.95	7.00	36.11	32.18	3.93	35.61	1.916
10:19:54 AM	26.1	26.1	6.95	7.00	36.11	32.18	3.93	35.61	1.916
10:20:05 AM	26.1	26.1	6.95	7.00	36.11	32.18	3.93	35.61	1.916
10:20:14 AM	26.1	26.1	6.96	7.01	35.29	31.45	3.84	34.79	1.873
10:20:25 AM	26.1	26.1	6.96	7.01	35.29	31.45	3.84	34.79	1.873
10:20:35 AM	26.1	26.1	6.96	7.01	35.29	31.45	3.84	34.79	1.873
10:20:44 AM	26.1	26.1	6.96	7.01	35.29	31.45	3.84	34.79	1.873
10:20:55 AM	26.1	26.1	6.96	7.02	35.29	30.73	4.55	34.79	2.222
10:21:04 AM	26.1	26.1	6.96	7.01	35.29	31.45	3.84	34.79	1.873
10:21:15 AM	26.1	26.1	6.97	7.02	34.48	30.73	3.75	33.98	1.830
10:21:25 AM	26.1	26.1	6.97	7.02	34.48	30.73	3.75	33.98	1.830
10:21:34 AM	26.1	26.1	6.97	7.01	34.48	31.45	3.03	33.98	1.481
10:21:45 AM	26.1	26.1	6.97	7.02	34.48	30.73	3.75	33.98	1.830
10:21:55 AM	26.1	26.1	6.97	7.02	34.48	30.73	3.75	33.98	1.830
10:22:04 AM	26.1	26.1	6.98	7.02	33.70	30.73	2.97	33.20	1.447
10:22:15 AM	26.1	26.1	6.98	7.03	33.70	30.03	3.66	33.20	1.788
10:22:25 AM	26.1	26.1	6.98	7.03	33.70	30.03	3.66	33.20	1.788
10:22:35 AM	26.1	26.1	6.98	7.02	33.70	30.73	2.97	33.20	1.447
10:22:45 AM	26.1	26.1	6.98	7.03	33.70	30.03	3.66	33.20	1.788
10:22:55 AM	26.1	26.1	6.98	7.03	33.70	30.03	3.66	33.20	1.788
10:23:05 AM	26.1	26.1	6.98	7.03	33.70	30.03	3.66	33.20	1.788
10:23:15 AM	26.1	26.1	6.99	7.03	32.93	30.03	2.90	32.43	1.414
10:23:25 AM	26.1	26.1	6.98	7.04	33.70	29.35	4.35	33.20	2.122
10:23:35 AM	26.1	26.1	6.99	7.04	32.93	29.35	3.58	32.43	1.748
10:23:45 AM	26.1	26.1	6.99	7.05	32.93	28.68	4.25	32.43	2.074
10:23:55 AM	26.1	26.1	6.99	7.06	32.93	28.03	4.90	32.43	2.392
10:24:05 AM	26.1	26.1	6.99	7.06	32.93	28.03	4.90	32.43	2.392

15.2 cm air-lift_Trial 1_8/25/2008 (continued)

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		$C_t - C_{out}$	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
10:24:14 AM	26.1	26.1	7.00	7.07	32.18	27.39	4.79	31.68	2.338
10:24:25 AM	26.1	26.1	6.99	7.07	32.93	27.39	5.54	32.43	2.704
10:24:35 AM	26.1	26.1	7.00	7.07	32.18	27.39	4.79	31.68	2.338
10:24:44 AM	26.1	26.1	7.00	7.07	32.18	27.39	4.79	31.68	2.338
10:24:55 AM	26.1	26.1	7.00	7.07	32.18	27.39	4.79	31.68	2.338
10:25:05 AM	26.1	26.1	7.00	7.07	32.18	27.39	4.79	31.68	2.338
10:25:14 AM	26.1	26.1	7.01	7.08	31.45	26.77	4.68	30.95	2.285
10:25:25 AM	26.1	26.1	7.01	7.08	31.45	26.77	4.68	30.95	2.285
10:25:35 AM	26.1	26.1	7.01	7.08	31.45	26.77	4.68	30.95	2.285
10:25:45 AM	26.1	26.1	7.01	7.08	31.45	26.77	4.68	30.95	2.285
10:25:55 AM	26.1	26.1	7.01	7.08	31.45	26.77	4.68	30.95	2.285
10:26:04 AM	26.1	26.1	7.01	7.09	31.45	26.16	5.29	30.95	2.582
10:26:15 AM	26.1	26.1	7.01	7.09	31.45	26.16	5.29	30.95	2.582
10:26:25 AM	26.1	26.1	7.01	7.09	31.45	26.16	5.29	30.95	2.582
10:26:35 AM	26.1	26.1	7.02	7.08	30.73	26.77	3.97	30.23	1.935
10:26:45 AM	26.1	26.1	7.02	7.10	30.73	25.56	5.17	30.23	2.523
10:26:54 AM	26.1	26.1	7.02	7.10	30.73	25.56	5.17	30.23	2.523
10:27:05 AM	26.1	26.1	7.02	7.10	30.73	25.56	5.17	30.23	2.523
10:27:15 AM	26.1	26.1	7.02	7.10	30.73	25.56	5.17	30.23	2.523
10:27:25 AM	26.1	26.1	7.02	7.10	30.73	25.56	5.17	30.23	2.523
10:27:35 AM	26.1	26.1	7.03	7.10	30.03	25.56	4.47	29.53	2.182
10:27:45 AM	26.1	26.1	7.03	7.08	30.03	26.77	3.27	29.53	1.594
10:27:55 AM	26.1	26.1	7.03	7.09	30.03	26.16	3.88	29.53	1.891
10:28:05 AM	26.1	26.1	7.03	7.09	30.03	26.16	3.88	29.53	1.891
10:28:15 AM	26.1	26.1	7.03	7.09	30.03	26.16	3.88	29.53	1.891
10:28:25 AM	26.1	26.1	7.03	7.10	30.03	25.56	4.47	29.53	2.182
10:28:35 AM	26.1	26.1	7.04	7.10	29.35	25.56	3.79	28.85	1.848
10:28:45 AM	26.1	26.1	7.04	7.10	29.35	25.56	3.79	28.85	1.848
10:28:55 AM	26.1	26.1	7.04	7.10	29.35	25.56	3.79	28.85	1.848
10:29:14 AM	26.1	26.1	7.04	7.11	29.35	24.98	4.37	28.85	2.132
10:30:13 AM	26.1	26.1	7.06	7.11	28.03	24.98	3.05	27.53	1.488
10:31:13 AM	26.1	26.1	7.06	7.11	28.03	24.98	3.05	27.53	1.488
10:32:13 AM	26.1	26.1	7.07	7.11	27.39	24.98	2.41	26.89	1.176
10:33:13 AM	26.1	26.1	7.08	7.12	26.77	24.41	2.36	26.27	1.149
10:34:13 AM	26.1	26.1	7.10	7.14	25.56	23.31	2.25	25.06	1.098

15.2 cm air-lift_Trial 1_8/25/2008 (continued)

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		$C_t - C_{out}$	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
10:35:13 AM	26.1	26.1	7.10	7.14	25.56	23.31	2.25	25.06	1.098
10:36:13 AM	26.1	26.1	7.11	7.15	24.98	22.78	2.20	24.48	1.073
10:37:13 AM	26.1	26.1	7.12	7.16	24.41	22.26	2.15	23.91	1.048
10:38:13 AM	26.1	26.1	7.13	7.17	23.86	21.81	2.05	23.36	1.000
10:39:13 AM	26.1	26.1	7.14	7.18	23.31	21.26	2.05	22.81	1.001
10:40:13 AM	26.1	26.1	7.15	7.19	22.78	20.92	1.86	22.28	0.908
10:41:13 AM	26.1	26.1	7.16	7.20	22.26	20.49	1.77	21.76	0.864
10:42:13 AM	26.1	26.1	7.17	7.21	21.76	20.07	1.68	21.26	0.822
10:43:13 AM	26.1	26.1	7.17	7.21	21.76	19.66	2.10	21.26	1.023
10:44:13 AM	26.1	26.1	7.18	7.22	21.26	19.26	2.00	20.76	0.978
10:45:13 AM	26.1	26.1	7.19	7.23	20.78	18.86	1.92	20.28	0.935
10:46:13 AM	26.1	26.1	7.20	7.24	20.31	18.48	1.83	19.81	0.893
10:47:13 AM	26.1	26.1	7.21	7.28	19.84	16.89	2.95	19.34	1.442
10:48:13 AM	26.1	26.1	7.22	7.29	19.39	16.50	2.89	18.89	1.409
10:49:13 AM	26.1	26.1	7.23	7.32	18.95	15.40	3.55	18.45	1.731
10:50:13 AM	26.1	26.1	7.24	7.31	18.52	15.76	2.76	18.02	1.345
10:51:13 AM	26.1	26.1	7.24	7.33	18.52	15.05	3.47	18.02	1.691
10:52:13 AM	26.1	26.1	7.25	7.33	18.10	15.05	3.04	17.60	1.486
10:53:13 AM	26.1	26.1	7.26	7.34	17.68	14.71	2.98	17.18	1.452
10:54:13 AM	26.1	26.1	7.27	7.35	17.28	14.37	2.91	16.78	1.419
10:55:13 AM	26.1	26.1	7.28	7.36	16.89	14.05	2.84	16.39	1.387
10:56:13 AM	26.1	26.1	7.29	7.37	16.50	13.73	2.78	16.00	1.355
10:57:13 AM	26.1	26.1	7.30	7.38	16.13	13.42	2.71	15.63	1.324
10:58:13 AM	26.1	26.1	7.31	7.38	15.76	13.42	2.35	15.26	1.145
10:59:13 AM	26.1	26.1	7.31	7.39	15.76	13.11	2.65	15.26	1.294
11:00:13 AM	26.1	26.1	7.32	7.38	15.40	13.42	1.99	14.90	0.970
11:01:13 AM	26.1	26.1	7.33	7.41	15.05	12.52	2.53	14.55	1.236
11:02:13 AM	26.1	26.1	7.34	7.41	14.71	12.52	2.19	14.21	1.069
11:03:13 AM	26.1	26.1	7.35	7.42	14.37	12.24	2.14	13.87	1.044
11:04:13 AM	26.1	26.1	7.36	7.42	14.05	12.24	1.81	13.55	0.885
11:05:13 AM	26.1	26.1	7.36	7.43	14.05	11.96	2.09	13.55	1.021
11:06:13 AM	26.1	26.1	7.37	7.43	13.73	11.96	1.77	13.23	0.864
11:07:13 AM	26.1	26.1	7.38	7.45	13.42	11.42	2.00	12.92	0.975
11:08:13 AM	26.1	26.1	7.39	7.46	13.11	11.16	1.95	12.61	0.952
11:09:13 AM	26.1	26.1	7.40	7.44	12.81	11.68	1.13	12.31	0.550

15.2 cm air-lift_Trial 1_8/25/2008 (continued)

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		$C_t - C_{out}$	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
11:10:13 AM	26.2	26.1	7.41	7.46	12.52	11.16	1.36	12.02	0.664
11:11:13 AM	26.2	26.1	7.42	7.48	12.24	10.66	1.58	11.74	0.770
11:12:13 AM	26.2	26.1	7.42	7.48	12.24	10.66	1.58	11.74	0.770
11:13:13 AM	26.2	26.1	7.43	7.49	11.96	10.41	1.54	11.46	0.753
11:14:13 AM	26.2	26.1	7.44	7.50	11.68	10.18	1.51	11.18	0.736
11:15:13 AM	26.2	26.1	7.45	7.48	11.42	10.66	0.76	10.92	0.372
11:16:13 AM	26.2	26.1	7.45	7.50	11.42	10.18	1.24	10.92	0.606
11:17:13 AM	26.2	26.1	7.46	7.52	11.16	9.72	1.44	10.66	0.703
11:18:13 AM	26.2	26.1	7.47	7.53	10.90	9.50	1.41	10.40	0.687
11:19:13 AM	26.2	26.1	7.48	7.52	10.66	9.72	0.94	10.16	0.458
11:20:13 AM	26.2	26.1	7.48	7.54	10.66	9.28	1.38	10.16	0.671
11:21:13 AM	26.2	26.1	7.49	7.55	10.41	9.07	1.34	9.91	0.656
11:22:13 AM	26.2	26.1	7.50	7.55	10.18	9.07	1.11	9.68	0.540
11:23:13 AM	26.2	26.1	7.51	7.54	9.95	9.28	0.66	9.45	0.324
11:24:13 AM	26.2	26.1	7.51	7.56	9.95	8.86	1.08	9.45	0.528

15.2 cm air-lift_Trial 2_8/25/2008

Hydraulic and Alkalinity Summary

Time	Volume [liters]	Fill time [sec]	Q_L [l min^{-1}]	Alk [mg l^{-1}]
11:45 AM	20.06	3.55	339.04	160
12:30 PM	20.06	3.59	335.26	155
1:00 PM	20.06	3.46	347.86	158
1:15 PM	20.06	3.49	344.87	156

Lift	38.1	cm	$Q_{L,ave}$	341.76	l min^{-1}
C_s	0.5	mg l^{-1}	$Q_{G,ave}$	495.00	l min^{-1}
FW_{CO2}	44.01	g mol^{-1}	Q_G:Q_L	1.45	
V_{tank}	7973.3	liters	Alkalinity	157	mg $CaCO_3$ l^{-1}

15.2 cm air-lift_Trial 2_8/25/2008 (continued)

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		$C_t - C_{out}$	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
11:42:08 AM	26.2	26.1	7.56	7.55	8.86	9.07	-0.21	8.36	-0.102
11:42:18 AM	26.2	26.1	7.56	7.55	8.86	9.07	-0.21	8.36	-0.102
11:42:28 AM	26.2	26.1	7.55	7.55	9.07	9.07	0.00	8.57	0.000
11:42:38 AM	26.2	26.1	7.56	7.53	8.86	9.50	-0.63	8.36	-0.312
11:42:48 AM	26.2	26.1	7.55	7.30	9.07	16.13	-7.06	8.57	-3.474
11:42:59 AM	26.2	26.1	7.55	7.04	9.07	29.35	-20.28	8.57	-9.980
11:43:07 AM	26.2	26.1	7.22	7.01	19.39	31.45	-12.06	18.89	-5.934
11:43:17 AM	26.2	26.1	7.13	6.98	23.86	33.70	-9.84	23.36	-4.843
11:43:27 AM	26.2	26.1	7.02	6.95	30.73	36.11	-5.38	30.23	-2.645
11:43:37 AM	26.2	26.1	6.97	6.98	34.48	33.70	0.78	33.98	0.386
11:43:47 AM	26.2	26.1	6.90	6.92	40.51	38.69	1.82	40.01	0.897
11:43:57 AM	26.2	26.1	6.89	6.82	41.46	48.71	-7.25	40.96	-3.568
11:44:09 AM	26.2	26.1	6.80	6.87	51.00	43.41	7.59	50.50	3.737
11:44:18 AM	26.2	26.1	6.78	6.78	53.41	53.41	0.00	52.91	0.000
11:44:28 AM	26.2	26.1	6.77	6.75	54.65	57.23	-2.58	54.15	-1.268
11:44:38 AM	26.2	26.1	6.75	6.75	57.23	57.23	0.00	56.73	0.000
11:44:48 AM	26.2	26.1	6.74	6.75	58.56	57.23	1.33	58.06	0.656
11:44:58 AM	26.2	26.1	6.72	6.80	61.32	51.00	10.32	60.82	5.077
11:45:08 AM	26.2	26.1	6.75	6.83	57.23	47.60	9.63	56.73	4.738
11:45:19 AM	26.2	26.1	6.77	6.81	54.65	49.84	4.81	54.15	2.367
11:45:27 AM	26.2	26.1	6.76	6.81	55.92	49.84	6.08	55.42	2.993
11:45:37 AM	26.2	26.1	6.75	6.82	57.23	48.71	8.52	56.73	4.192
11:45:48 AM	26.2	26.1	6.76	6.82	55.92	48.71	7.22	55.42	3.551
11:45:57 AM	26.2	26.1	6.75	6.84	57.23	46.52	10.71	56.73	5.271
11:46:07 AM	26.2	26.1	6.75	6.83	57.23	47.60	9.63	56.73	4.738
11:46:19 AM	26.2	26.1	6.77	6.84	54.65	46.52	8.14	54.15	4.004
11:46:28 AM	26.2	26.1	6.77	6.85	54.65	45.46	9.19	54.15	4.525
11:46:38 AM	26.2	26.1	6.76	6.85	55.92	45.46	10.47	55.42	5.151
11:46:48 AM	26.2	26.1	6.76	6.84	55.92	46.52	9.41	55.42	4.630
11:46:58 AM	26.2	26.1	6.77	6.84	54.65	46.52	8.14	54.15	4.004
11:47:08 AM	26.2	26.1	6.77	6.86	54.65	44.42	10.23	54.15	5.034
11:47:17 AM	26.2	26.1	6.77	6.86	54.65	44.42	10.23	54.15	5.034
11:47:27 AM	26.2	26.1	6.77	6.86	54.65	44.42	10.23	54.15	5.034
11:47:38 AM	26.2	26.1	6.77	6.86	54.65	44.42	10.23	54.15	5.034
11:47:48 AM	26.2	26.1	6.77	6.85	54.65	45.46	9.19	54.15	4.525

15.2 cm air-lift_Trial 2_8/25/2008 (continued)

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		$C_t - C_{out}$	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
11:47:58 AM	26.2	26.1	6.77	6.85	54.65	45.46	9.19	54.15	4.525
11:48:08 AM	26.2	26.1	6.77	6.87	54.65	43.41	11.24	54.15	5.532
11:48:27 AM	26.2	26.1	6.77	6.86	54.65	44.42	10.23	54.15	5.034
11:49:27 AM	26.2	26.1	6.78	6.87	53.41	43.41	10.00	52.91	4.920
11:50:27 AM	26.2	26.1	6.79	6.88	52.19	42.42	9.77	51.69	4.808
11:51:27 AM	26.2	26.1	6.80	6.90	51.00	40.51	10.49	50.50	5.163
11:52:27 AM	26.2	26.1	6.80	6.89	51.00	41.46	9.55	50.50	4.698
11:53:27 AM	26.2	26.1	6.81	6.89	49.84	41.46	8.39	49.34	4.127
11:54:27 AM	26.2	26.1	6.82	6.91	48.71	39.59	9.12	48.21	4.487
11:55:27 AM	26.2	26.1	6.83	6.93	47.60	37.81	9.79	47.10	4.818
11:56:27 AM	26.2	26.1	6.84	6.92	46.52	38.69	7.83	46.02	3.851
11:57:27 AM	26.2	26.1	6.85	6.94	45.46	36.95	8.51	44.96	4.187
11:58:27 AM	26.2	26.2	6.86	6.96	44.42	35.29	9.14	43.92	4.496
11:59:27 AM	26.2	26.2	6.87	6.96	43.41	35.29	8.13	42.91	3.999
12:00:27 PM	26.2	26.2	6.88	6.97	42.42	34.48	7.94	41.92	3.908
12:01:27 PM	26.2	26.2	6.89	6.98	41.46	33.70	7.76	40.96	3.819
12:02:27 PM	26.2	26.2	6.89	6.99	41.46	32.93	8.53	40.96	4.196
12:03:27 PM	26.2	26.2	6.90	7.00	40.51	32.18	8.33	40.01	4.101
12:04:27 PM	26.2	26.2	6.92	7.01	38.69	31.45	7.24	38.19	3.564
12:05:27 PM	26.2	26.2	6.92	7.01	38.69	31.45	7.24	38.19	3.564
12:06:27 PM	26.2	26.2	6.93	7.02	37.81	30.73	7.08	37.31	3.483
12:07:27 PM	26.2	26.2	6.94	7.03	36.95	30.03	6.92	36.45	3.403
12:08:27 PM	26.2	26.2	6.95	7.06	36.11	28.03	8.08	35.61	3.976
12:09:27 PM	26.2	26.2	6.96	7.06	35.29	28.03	7.26	34.79	3.572
12:10:27 PM	26.2	26.2	6.97	7.06	34.48	28.03	6.45	33.98	3.176
12:11:27 PM	26.2	26.2	6.98	7.07	33.70	27.39	6.31	33.20	3.104
12:12:27 PM	26.2	26.2	6.99	7.07	32.93	27.39	5.54	32.43	2.727
12:13:27 PM	26.2	26.2	7.00	7.09	32.18	26.16	6.02	31.68	2.964
12:14:27 PM	26.2	26.2	7.01	7.10	31.45	25.56	5.89	30.95	2.897
12:15:27 PM	26.2	26.2	7.02	7.12	30.73	24.41	6.32	30.23	3.111
12:16:27 PM	26.2	26.2	7.03	7.12	30.03	24.41	5.62	29.53	2.766
12:17:27 PM	26.2	26.2	7.04	7.13	29.35	23.86	5.49	28.85	2.703
12:18:27 PM	26.2	26.2	7.04	7.15	29.35	22.78	6.57	28.85	3.232
12:19:27 PM	26.2	26.2	7.06	7.15	28.03	22.78	5.25	27.53	2.582
12:20:27 PM	26.2	26.2	7.06	7.16	28.03	22.26	5.76	27.53	2.837

15.2 cm air-lift_Trial 2_8/25/2008 (continued)

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		$C_t - C_{out}$	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
12:21:27 PM	26.2	26.2	7.07	7.16	27.39	22.26	5.13	26.89	2.523
12:22:27 PM	26.2	26.2	7.08	7.17	26.77	21.76	5.01	26.27	2.466
12:23:27 PM	26.2	26.2	7.09	7.18	26.16	21.26	4.90	25.66	2.409
12:24:27 PM	26.2	26.2	7.10	7.18	25.56	21.26	4.30	25.06	2.116
12:25:27 PM	26.2	26.2	7.11	7.21	24.98	19.84	5.14	24.48	2.529
12:26:27 PM	26.2	26.2	7.12	7.21	24.41	19.84	4.57	23.91	2.249
12:27:27 PM	26.2	26.2	7.12	7.22	24.41	19.39	5.02	23.91	2.471
12:28:27 PM	26.2	26.2	7.13	7.22	23.86	19.39	4.47	23.36	2.197
12:29:27 PM	26.2	26.2	7.15	7.23	22.78	18.95	3.83	22.28	1.886
12:30:27 PM	26.2	26.2	7.15	7.24	22.78	18.52	4.26	22.28	2.099
12:31:27 PM	26.2	26.2	7.16	7.23	22.26	18.95	3.31	21.76	1.631
12:32:27 PM	26.2	26.2	7.17	7.26	21.76	17.68	4.07	21.26	2.004
12:33:27 PM	26.2	26.2	7.18	7.26	21.26	17.68	3.58	20.76	1.760
12:34:27 PM	26.2	26.2	7.19	7.27	20.78	17.28	3.50	20.28	1.720
12:35:27 PM	26.2	26.2	7.20	7.27	20.31	17.28	3.02	19.81	1.488
12:36:27 PM	26.2	26.2	7.21	7.28	19.84	16.89	2.95	19.34	1.454
12:37:27 PM	26.2	26.2	7.22	7.30	19.39	16.13	3.26	18.89	1.605
12:38:27 PM	26.2	26.2	7.22	7.29	19.39	16.50	2.89	18.89	1.421
12:39:27 PM	26.2	26.2	7.23	7.30	18.95	16.13	2.82	18.45	1.388
12:40:27 PM	26.2	26.2	7.24	7.33	18.52	15.05	3.47	18.02	1.706
12:41:27 PM	26.2	26.2	7.25	7.32	18.10	15.40	2.69	17.60	1.326
12:42:27 PM	26.2	26.2	7.26	7.33	17.68	15.05	2.63	17.18	1.296
12:43:27 PM	26.2	26.2	7.27	7.33	17.28	15.05	2.23	16.78	1.097
12:44:27 PM	26.2	26.2	7.28	7.36	16.89	14.05	2.84	16.39	1.398
12:45:27 PM	26.2	26.2	7.29	7.35	16.50	14.37	2.13	16.00	1.048
12:46:27 PM	26.2	26.2	7.30	7.36	16.13	14.05	2.08	15.63	1.024
12:47:27 PM	26.2	26.2	7.31	7.38	15.76	13.42	2.35	15.26	1.155
12:48:27 PM	26.2	26.2	7.31	7.39	15.76	13.11	2.65	15.26	1.305
12:49:27 PM	26.2	26.2	7.32	7.39	15.40	13.11	2.29	14.90	1.128
12:50:27 PM	26.2	26.2	7.33	7.40	15.05	12.81	2.24	14.55	1.103
12:51:27 PM	26.2	26.2	7.34	7.41	14.71	12.52	2.19	14.21	1.078
12:52:27 PM	26.2	26.2	7.35	7.42	14.37	12.24	2.14	13.87	1.053
12:53:27 PM	26.2	26.2	7.36	7.43	14.05	11.96	2.09	13.55	1.029
12:54:27 PM	26.2	26.2	7.37	7.42	13.73	12.24	1.49	13.23	0.735
12:55:27 PM	26.2	26.2	7.37	7.44	13.73	11.68	2.04	13.23	1.006

15.2 cm air-lift_Trial 2_8/25/2008 (continued)

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		$C_t - C_{out}$	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
12:56:27 PM	26.2	26.2	7.38	7.44	13.42	11.68	1.73	12.92	0.852
12:57:27 PM	26.2	26.2	7.39	7.46	13.11	11.16	1.95	12.61	0.960
12:58:27 PM	26.2	26.2	7.40	7.47	12.81	10.90	1.91	12.31	0.939
12:59:27 PM	26.2	26.2	7.40	7.47	12.81	10.90	1.91	12.31	0.939
1:00:27 PM	26.2	26.2	7.42	7.48	12.24	10.66	1.58	11.74	0.777
1:01:27 PM	26.2	26.2	7.42	7.48	12.24	10.66	1.58	11.74	0.777
1:02:27 PM	26.2	26.2	7.43	7.49	11.96	10.41	1.54	11.46	0.759
1:03:27 PM	26.2	26.2	7.44	7.50	11.68	10.18	1.51	11.18	0.742
1:04:27 PM	26.3	26.2	7.45	7.50	11.42	10.18	1.24	10.92	0.611
1:05:27 PM	26.3	26.2	7.46	7.51	11.16	9.95	1.21	10.66	0.597
1:06:27 PM	26.3	26.2	7.46	7.51	11.16	9.95	1.21	10.66	0.597
1:07:27 PM	26.3	26.2	7.47	7.53	10.90	9.50	1.41	10.40	0.692
1:08:27 PM	26.3	26.2	7.48	7.53	10.66	9.50	1.16	10.16	0.570
1:09:27 PM	26.3	26.2	7.49	7.53	10.41	9.50	0.92	9.91	0.451
1:10:27 PM	26.3	26.2	7.50	7.55	10.18	9.07	1.11	9.68	0.545
1:11:27 PM	26.3	26.2	7.50	7.55	10.18	9.07	1.11	9.68	0.545
1:12:27 PM	26.3	26.2	7.51	7.56	9.95	8.86	1.08	9.45	0.532

15.2 cm air-lift_Trial 3_8/25/2008

Hydraulic and Alkalinity Summary

Time	Volume [liters]	Fill time [sec]	Q_L [l min^{-1}]	Alk [mg l^{-1}]
2:00 PM	20.06	3.56	338.09	157
2:45 PM	20.06	3.62	332.49	155
3:15 PM	20.06	3.44	349.88	154
3:35 PM	20.06	3.52	341.93	158

Lift	38.1	cm	$Q_{L,ave}$	340.60	l min^{-1}
C_s	0.5	mg l^{-1}	$Q_{G,ave}$	495.00	l min^{-1}
FW_{CO2}	44.01	g mol^{-1}	Q_G:Q_L	1.45	
V_{tank}	7973.3	liters	Alkalinity	156	mg $CaCO_3$ l^{-1}

15.2 cm air-lift_Trial 3_8/25/2008 (continued)

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		$C_t - C_{out}$	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
1:54:43 PM	26.3	26.3	7.66	7.66	6.98	6.98	0.00	6.48	0.000
1:54:53 PM	26.3	26.3	7.66	7.66	6.98	6.98	0.00	6.48	0.000
1:55:04 PM	26.3	26.3	7.65	7.54	7.15	9.21	-2.06	6.65	-1.010
1:55:13 PM	26.3	26.3	7.62	7.39	7.66	13.01	-5.35	7.16	-2.623
1:55:23 PM	26.3	26.3	7.50	7.04	10.10	29.12	-19.02	9.60	-9.329
1:55:33 PM	26.3	26.3	7.21	6.93	19.69	37.51	-17.82	19.19	-8.742
1:55:44 PM	26.3	26.3	7.13	7.01	23.67	31.20	-7.53	23.17	-3.694
1:55:53 PM	26.3	26.3	7.05	7.01	28.45	31.20	-2.75	27.95	-1.346
1:56:03 PM	26.3	26.3	7.01	6.94	31.20	36.66	-5.46	30.70	-2.676
1:56:13 PM	26.3	26.3	6.94	6.91	36.66	39.28	-2.62	36.16	-1.286
1:56:24 PM	26.3	26.3	6.90	6.93	40.19	37.51	2.68	39.69	1.316
1:56:33 PM	26.3	26.3	6.83	6.81	47.22	49.45	-2.23	46.72	-1.092
1:56:43 PM	26.3	26.3	6.81	6.80	49.45	50.60	-1.15	48.95	-0.565
1:56:53 PM	26.3	26.3	6.75	6.74	56.77	58.10	-1.32	56.27	-0.649
1:57:04 PM	26.3	26.3	6.71	6.77	62.25	54.22	8.03	61.75	3.940
1:57:13 PM	26.3	26.3	6.70	6.74	63.70	58.10	5.60	63.20	2.749
1:57:23 PM	26.3	26.3	6.72	6.73	60.83	59.45	1.38	60.33	0.679
1:57:33 PM	26.3	26.3	6.70	6.73	63.70	59.45	4.25	63.20	2.085
1:57:43 PM	26.3	26.3	6.70	6.71	63.70	62.25	1.45	63.20	0.711
1:57:53 PM	26.3	26.3	6.71	6.74	62.25	58.10	4.15	61.75	2.038
1:58:03 PM	26.3	26.3	6.70	6.70	63.70	63.70	0.00	63.20	0.000
1:58:14 PM	26.3	26.3	6.71	6.70	62.25	63.70	-1.45	61.75	-0.711
1:58:23 PM	26.3	26.3	6.71	6.72	62.25	60.83	1.42	61.75	0.695
1:58:33 PM	26.3	26.3	6.71	6.73	62.25	59.45	2.80	61.75	1.374
1:58:44 PM	26.3	26.3	6.72	6.74	60.83	58.10	2.74	60.33	1.343
1:58:53 PM	26.3	26.3	6.72	6.77	60.83	54.22	6.62	60.33	3.245
1:59:03 PM	26.3	26.3	6.72	6.77	60.83	54.22	6.62	60.33	3.245
1:59:14 PM	26.3	26.3	6.72	6.76	60.83	55.48	5.35	60.33	2.625
1:59:23 PM	26.3	26.3	6.72	6.76	60.83	55.48	5.35	60.33	2.625
1:59:33 PM	26.3	26.3	6.72	6.76	60.83	55.48	5.35	60.33	2.625
1:59:47 PM	26.3	26.3	6.72	6.77	60.83	54.22	6.62	60.33	3.245
2:00:47 PM	26.3	26.3	6.72	6.79	60.83	51.78	9.06	60.33	4.441
2:01:47 PM	26.3	26.3	6.73	6.79	59.45	51.78	7.67	58.95	3.762
2:02:47 PM	26.3	26.3	6.74	6.79	58.10	51.78	6.32	57.60	3.099
2:03:47 PM	26.3	26.3	6.74	6.81	58.10	49.45	8.65	57.60	4.242

15.2 cm air-lift_Trial 3_8/25/2008 (continued)

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		$C_t - C_{out}$	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
2:04:47 PM	26.3	26.3	6.76	6.82	55.48	48.32	7.16	54.98	3.511
2:05:47 PM	26.3	26.3	6.76	6.82	55.48	48.32	7.16	54.98	3.511
2:06:47 PM	26.3	26.3	6.77	6.83	54.22	47.22	7.00	53.72	3.431
2:07:47 PM	26.3	26.3	6.77	6.84	54.22	46.15	8.07	53.72	3.958
2:08:47 PM	26.3	26.3	6.78	6.85	52.98	45.10	7.89	52.48	3.868
2:09:47 PM	26.3	26.3	6.79	6.87	51.78	43.07	8.71	51.28	4.272
2:10:47 PM	26.3	26.3	6.80	6.88	50.60	42.09	8.51	50.10	4.175
2:11:47 PM	26.3	26.3	6.81	6.88	49.45	42.09	7.36	48.95	3.610
2:12:47 PM	26.3	26.3	6.82	6.89	48.32	41.13	7.19	47.82	3.528
2:13:47 PM	26.3	26.3	6.82	6.91	48.32	39.28	9.04	47.82	4.436
2:14:47 PM	26.3	26.3	6.84	6.92	46.15	38.38	7.76	45.65	3.808
2:15:47 PM	26.3	26.3	6.84	6.93	46.15	37.51	8.64	45.65	4.236
2:16:47 PM	26.3	26.3	6.84	6.94	46.15	36.66	9.49	45.65	4.655
2:17:47 PM	26.3	26.3	6.87	6.95	43.07	35.82	7.25	42.57	3.554
2:18:47 PM	26.3	26.3	6.88	6.96	42.09	35.01	7.08	41.59	3.473
2:19:47 PM	26.3	26.3	6.89	6.97	41.13	34.21	6.92	40.63	3.394
2:20:47 PM	26.3	26.3	6.90	6.97	40.19	34.21	5.98	39.69	2.934
2:21:47 PM	26.3	26.3	6.91	6.99	39.28	32.67	6.61	38.78	3.241
2:22:47 PM	26.3	26.3	6.92	6.99	38.38	32.67	5.71	37.88	2.802
2:23:47 PM	26.3	26.3	6.93	7.01	37.51	31.20	6.31	37.01	3.095
2:24:47 PM	26.3	26.3	6.93	7.02	37.51	30.49	7.02	37.01	3.443
2:25:47 PM	26.3	26.3	6.94	7.03	36.66	29.79	6.86	36.16	3.365
2:26:47 PM	26.3	26.3	6.96	7.03	35.01	29.79	5.21	34.51	2.556
2:27:47 PM	26.3	26.3	6.96	7.04	35.01	29.12	5.89	34.51	2.888
2:28:47 PM	26.3	26.3	6.98	7.06	33.43	27.81	5.62	32.93	2.758
2:29:47 PM	26.3	26.3	6.98	7.07	33.43	27.17	6.26	32.93	3.069
2:30:47 PM	26.3	26.3	6.99	7.07	32.67	27.17	5.50	32.17	2.696
2:31:47 PM	26.3	26.3	7.00	7.09	31.93	25.95	5.98	31.43	2.931
2:32:47 PM	26.3	26.3	7.01	7.09	31.20	25.95	5.25	30.70	2.574
2:33:47 PM	26.3	26.3	7.02	7.10	30.49	25.36	5.13	29.99	2.516
2:34:47 PM	26.3	26.3	7.03	7.11	29.79	24.78	5.01	29.29	2.458
2:35:47 PM	26.3	26.3	7.04	7.12	29.12	24.22	4.90	28.62	2.402
2:36:47 PM	26.3	26.3	7.06	7.13	27.81	23.67	4.14	27.31	2.030
2:37:47 PM	26.3	26.3	7.06	7.14	27.81	23.13	4.68	27.31	2.294
2:38:47 PM	26.3	26.3	7.07	7.15	27.17	22.60	4.57	26.67	2.242

15.2 cm air-lift_Trial 3_8/25/2008 (continued)

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		$C_t - C_{out}$	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
2:39:47 PM	26.3	26.3	7.08	7.16	26.55	22.09	4.47	26.05	2.191
2:40:47 PM	26.3	26.3	7.09	7.17	25.95	21.58	4.37	25.45	2.141
2:41:47 PM	26.3	26.3	7.10	7.19	25.36	20.61	4.75	24.86	2.328
2:42:47 PM	26.3	26.3	7.11	7.19	24.78	20.61	4.17	24.28	2.045
2:43:47 PM	26.3	26.3	7.12	7.20	24.22	20.14	4.07	23.72	1.998
2:44:47 PM	26.3	26.3	7.13	7.21	23.67	19.69	3.98	23.17	1.953
2:45:47 PM	26.3	26.3	7.14	7.22	23.13	19.24	3.89	22.63	1.908
2:46:47 PM	26.3	26.3	7.15	7.22	22.60	19.24	3.36	22.10	1.650
2:47:47 PM	26.3	26.3	7.15	7.23	22.60	18.80	3.80	22.10	1.865
2:48:47 PM	26.4	26.3	7.16	7.25	22.09	17.95	4.13	21.59	2.028
2:49:47 PM	26.4	26.3	7.18	7.26	21.09	17.54	3.55	20.59	1.740
2:50:47 PM	26.4	26.3	7.18	7.26	21.09	17.54	3.55	20.59	1.740
2:51:47 PM	26.4	26.3	7.20	7.28	20.14	16.75	3.39	19.64	1.662
2:52:47 PM	26.4	26.3	7.20	7.28	20.14	16.75	3.39	19.64	1.662
2:53:47 PM	26.4	26.3	7.21	7.29	19.69	16.37	3.31	19.19	1.624
2:54:47 PM	26.4	26.3	7.22	7.29	19.24	16.37	2.86	18.74	1.405
2:55:47 PM	26.4	26.3	7.23	7.30	18.80	16.00	2.80	18.30	1.373
2:56:47 PM	26.4	26.3	7.24	7.32	18.37	15.28	3.09	17.87	1.516
2:57:47 PM	26.4	26.3	7.25	7.33	17.95	14.93	3.02	17.45	1.481
2:58:47 PM	26.4	26.3	7.26	7.33	17.54	14.93	2.61	17.04	1.281
2:59:47 PM	26.4	26.3	7.27	7.34	17.15	14.59	2.55	16.65	1.252
3:00:47 PM	26.4	26.3	7.28	7.35	16.75	14.26	2.49	16.25	1.223
3:01:47 PM	26.4	26.3	7.29	7.36	16.37	13.94	2.44	15.87	1.195
3:02:47 PM	26.4	26.3	7.29	7.37	16.37	13.62	2.75	15.87	1.351
3:03:47 PM	26.4	26.3	7.30	7.37	16.00	13.62	2.38	15.50	1.168
3:04:47 PM	26.4	26.3	7.31	7.38	15.64	13.31	2.33	15.14	1.142
3:05:47 PM	26.4	26.3	7.32	7.40	15.28	12.71	2.57	14.78	1.261
3:06:47 PM	26.4	26.3	7.34	7.40	14.59	12.71	1.88	14.09	0.924
3:07:47 PM	26.4	26.3	7.35	7.41	14.26	12.42	1.84	13.76	0.903
3:08:47 PM	26.4	26.3	7.35	7.42	14.26	12.14	2.12	13.76	1.041
3:09:47 PM	26.4	26.3	7.35	7.42	14.26	12.14	2.12	13.76	1.041
3:10:47 PM	26.4	26.3	7.37	7.43	13.62	11.86	1.76	13.12	0.862
3:11:47 PM	26.4	26.3	7.38	7.44	13.31	11.59	1.72	12.81	0.842
3:12:47 PM	26.4	26.3	7.38	7.45	13.31	11.33	1.98	12.81	0.972
3:13:47 PM	26.4	26.3	7.39	7.46	13.01	11.07	1.94	12.51	0.950

15.2 cm air-lift_Trial 3_8/25/2008 (continued)

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		$C_t - C_{out}$	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
3:14:47 PM	26.4	26.3	7.40	7.47	12.71	10.82	1.89	12.21	0.928
3:15:47 PM	26.4	26.3	7.41	7.47	12.42	10.82	1.60	11.92	0.786
3:16:47 PM	26.4	26.3	7.42	7.48	12.14	10.57	1.57	11.64	0.768
3:17:47 PM	26.4	26.3	7.43	7.49	11.86	10.33	1.53	11.36	0.751
3:18:47 PM	26.4	26.3	7.43	7.51	11.86	9.87	2.00	11.36	0.979
3:19:47 PM	26.4	26.3	7.44	7.50	11.59	10.10	1.50	11.09	0.734
3:20:47 PM	26.4	26.3	7.45	7.52	11.33	9.64	1.69	10.83	0.827
3:21:47 PM	26.4	26.3	7.46	7.52	11.07	9.64	1.43	10.57	0.701
3:22:47 PM	26.4	26.3	7.47	7.53	10.82	9.42	1.40	10.32	0.685
3:23:47 PM	26.4	26.3	7.48	7.54	10.57	9.21	1.36	10.07	0.669
3:24:47 PM	26.4	26.3	7.49	7.54	10.33	9.21	1.12	9.83	0.551
3:25:47 PM	26.4	26.3	7.50	7.55	10.10	9.00	1.10	9.60	0.538

pH/Alkalinity CTR and $C_{deficit}$ Linear Regression Summary for 495 l min^{-1} air injection

Air-lift [cm]	Trial	Lift [cm]	CTR Coefficient for $C_{deficit}$ equations	R^2
15.2	1	38.1	$CTR = 0.0864*C_{deficit}$	0.942
15.2	2	38.1	$CTR = 0.0905*C_{deficit}$	0.959
15.2	3	38.1	$CTR = 0.0822*C_{deficit}$	0.966

pH/Alkalinity K_La and SCTR Summary for 495 l min^{-1} air injection

		K_La [min^{-1}]		K_La_{20} [min^{-1}]		SCTR [kg hr^{-1}]	
Air-lift [cm]	Trial	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet
15.2	1	0.022	0.022	0.019	0.019	0.0045	0.0046
15.2	2	0.021	0.020	0.018	0.017	0.0044	0.0042
15.2	3	0.022	0.022	0.019	0.019	0.0045	0.0044
	Ave	**0.022**	**0.021**	**0.019**	**0.018**	**0.0045**	**0.0044**
	St. D.	**0.000**	**0.001**	**0.000**	**0.001**	**0.0001**	**0.0002**

DEGASSING STUDIES_pH/Alkalinity Method (continued)

20.3 cm air-lift_580 l air min^{-1}

20.3 cm air-lift_Trial 1_8/26/2008

Hydraulic and Alkalinity Summary

Time	Volume [liters]	Fill time [sec]	Q_L [l min^{-1}]	Alk [mg l^{-1}]
1:00 PM	20.06	2.40	501.50	160
1:15 PM	20.06	2.35	512.17	158
1:45 PM	20.06	2.44	493.28	157
2:15 PM	20.06	2.41	499.42	158

Lift	30	cm	$Q_{L,ave}$	501.59	l min^{-1}
C_s	0.5	mg l^{-1}	$Q_{G,ave}$	580.40	l min^{-1}
FW_{CO2}	44.01	g mol^{-1}	Q_G:Q_L	1.16	
V_{tank}	8436.9	liters	Alkalinity	158	mg $CaCO_3$ l^{-1}

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		C_t - C_{out}	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
12:55:28 PM	26.5	26.5	7.45	7.45	11.52	11.52	0.00	11.02	0.000
12:55:38 PM	26.5	26.5	7.45	7.46	11.52	11.25	0.26	11.02	0.189
12:55:49 PM	26.5	26.4	7.44	7.45	11.78	11.52	0.27	11.28	0.194
12:55:58 PM	26.5	26.5	7.31	7.34	15.90	14.84	1.06	15.40	0.766
12:56:08 PM	26.5	26.5	7.16	7.17	22.46	21.94	0.51	21.96	0.369
12:56:18 PM	26.5	26.5	7.11	7.09	25.20	26.38	-1.19	24.70	-0.858
12:56:29 PM	26.5	26.5	7.11	7.12	25.20	24.62	0.57	24.70	0.414
12:56:38 PM	26.5	26.5	7.05	7.07	28.93	27.63	1.30	28.43	0.940
12:56:48 PM	26.5	26.5	6.95	6.96	36.42	35.59	0.83	35.92	0.599
12:56:58 PM	26.5	26.5	6.95	6.94	36.42	37.27	-0.85	35.92	-0.613
12:57:10 PM	26.5	26.5	6.88	6.87	42.79	43.78	-1.00	42.29	-0.720
12:57:18 PM	26.5	26.5	6.93	6.92	38.13	39.02	-0.89	37.63	-0.642
12:57:28 PM	26.5	26.5	6.87	6.86	43.78	44.80	-1.02	43.28	-0.737
12:57:38 PM	26.5	26.5	6.83	6.82	48.01	49.13	-1.12	47.51	-0.808
12:57:48 PM	26.5	26.5	6.85	6.85	45.85	45.85	0.00	45.35	0.000
12:57:58 PM	26.5	26.5	6.77	6.81	55.12	50.27	4.85	54.62	3.503
12:58:08 PM	26.5	26.5	6.77	6.85	55.12	45.85	9.27	54.62	6.698

20.3 cm air-lift_Trial 1_8/26/2008 (continued)

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		$C_t - C_{out}$	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
12:58:18 PM	26.5	26.5	6.82	6.82	49.13	49.13	0.00	48.63	0.000
12:58:29 PM	26.5	26.5	6.77	6.79	55.12	52.64	2.48	54.62	1.792
12:58:38 PM	26.5	26.5	6.80	6.75	51.44	57.72	-6.28	50.94	-4.534
12:58:48 PM	26.5	26.5	6.75	6.77	57.72	55.12	2.60	57.22	1.876
12:58:58 PM	26.5	26.5	6.79	6.80	52.64	51.44	1.20	52.14	0.865
12:59:08 PM	26.5	26.5	6.77	6.79	55.12	52.64	2.48	54.62	1.792
12:59:18 PM	26.5	26.5	6.81	6.81	50.27	50.27	0.00	49.77	0.000
12:59:28 PM	26.5	26.5	6.82	6.84	49.13	46.92	2.21	48.63	1.597
12:59:40 PM	26.5	26.5	6.81	6.84	50.27	46.92	3.36	49.77	2.424
12:59:48 PM	26.5	26.5	6.79	6.85	52.64	45.85	6.79	52.14	4.906
12:59:58 PM	26.5	26.5	6.79	6.83	52.64	48.01	4.63	52.14	3.345
1:00:08 PM	26.5	26.5	6.79	6.84	52.64	46.92	5.72	52.14	4.135
1:00:18 PM	26.5	26.5	6.79	6.85	52.64	45.85	6.79	52.14	4.906
1:00:28 PM	26.5	26.5	6.79	6.87	52.64	43.78	8.86	52.14	6.397
1:00:38 PM	26.5	26.5	6.78	6.86	53.87	44.80	9.06	53.37	6.546
1:00:48 PM	26.5	26.5	6.80	6.85	51.44	45.85	5.59	50.94	4.041
1:00:58 PM	26.5	26.5	6.81	6.84	50.27	46.92	3.36	49.77	2.424
1:01:08 PM	26.5	26.5	6.81	6.87	50.27	43.78	6.49	49.77	4.685
1:01:18 PM	26.5	26.5	6.81	6.87	50.27	43.78	6.49	49.77	4.685
1:01:28 PM	26.5	26.5	6.80	6.86	51.44	44.80	6.64	50.94	4.794
1:01:39 PM	26.5	26.5	6.80	6.85	51.44	45.85	5.59	50.94	4.041
1:01:48 PM	26.5	26.5	6.80	6.87	51.44	43.78	7.66	50.94	5.531
1:01:58 PM	26.5	26.5	6.80	6.88	51.44	42.79	8.65	50.94	6.251
1:02:19 PM	26.5	26.5	6.80	6.88	51.44	42.79	8.65	50.94	6.251
1:03:19 PM	26.5	26.5	6.82	6.89	49.13	41.81	7.31	48.63	5.282
1:04:19 PM	26.5	26.5	6.84	6.89	46.92	41.81	5.10	46.42	3.685
1:05:19 PM	26.5	26.5	6.85	6.89	45.85	41.81	4.03	45.35	2.914
1:06:19 PM	26.5	26.5	6.85	6.92	45.85	39.02	6.82	45.35	4.930
1:07:19 PM	26.5	26.5	6.85	6.92	45.85	39.02	6.82	45.35	4.930
1:08:19 PM	26.5	26.5	6.85	6.94	45.85	37.27	8.58	45.35	6.198
1:09:19 PM	26.5	26.5	6.86	6.95	44.80	36.42	8.39	44.30	6.057
1:10:19 PM	26.5	26.5	6.87	6.97	43.78	34.78	9.01	43.28	6.504
1:11:19 PM	26.5	26.5	6.88	6.97	42.79	34.78	8.01	42.29	5.784
1:12:19 PM	26.5	26.5	6.89	6.99	41.81	33.21	8.60	41.31	6.212
1:13:19 PM	26.5	26.5	6.91	7.00	39.93	32.46	7.47	39.43	5.398

20.3 cm air-lift_Trial 1_8/26/2008 (continued)

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		$C_t - C_{out}$	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
1:14:19 PM	26.5	26.5	6.91	7.02	39.93	31.00	8.93	39.43	6.454
1:15:19 PM	26.5	26.5	6.92	7.02	39.02	31.00	8.03	38.52	5.797
1:16:19 PM	26.5	26.5	6.93	7.03	38.13	30.29	7.84	37.63	5.665
1:17:19 PM	26.5	26.5	6.94	7.03	37.27	30.29	6.98	36.77	5.038
1:18:19 PM	26.5	26.5	6.95	7.05	36.42	28.93	7.49	35.92	5.410
1:19:19 PM	26.5	26.5	6.96	7.08	35.59	27.00	8.59	35.09	6.206
1:20:19 PM	26.5	26.5	6.97	7.07	34.78	27.63	7.15	34.28	5.167
1:21:19 PM	26.5	26.5	6.98	7.10	33.99	25.78	8.21	33.49	5.927
1:22:19 PM	26.5	26.5	7.00	7.10	32.46	25.78	6.68	31.96	4.822
1:23:19 PM	26.5	26.5	7.01	7.11	31.72	25.20	6.52	31.22	4.712
1:24:19 PM	26.5	26.5	7.02	7.12	31.00	24.62	6.38	30.50	4.605
1:25:19 PM	26.5	26.5	7.03	7.12	30.29	24.62	5.67	29.79	4.095
1:26:19 PM	26.5	26.5	7.04	7.15	29.60	22.98	6.62	29.10	4.784
1:27:19 PM	26.5	26.5	7.05	7.15	28.93	22.98	5.95	28.43	4.297
1:28:19 PM	26.5	26.5	7.06	7.16	28.27	22.46	5.81	27.77	4.200
1:29:19 PM	26.5	26.5	7.08	7.18	27.00	21.44	5.55	26.50	4.011
1:30:19 PM	26.5	26.5	7.09	7.19	26.38	20.96	5.43	25.88	3.919
1:31:19 PM	26.5	26.5	7.09	7.20	26.38	20.48	5.90	25.88	4.264
1:32:19 PM	26.5	26.5	7.11	7.21	25.20	20.01	5.18	24.70	3.743
1:33:19 PM	26.5	26.5	7.12	7.22	24.62	19.56	5.06	24.12	3.658
1:34:19 PM	26.5	26.5	7.14	7.23	23.51	19.11	4.40	23.01	3.179
1:35:19 PM	26.6	26.5	7.14	7.23	23.51	19.11	4.40	23.01	3.179
1:36:19 PM	26.6	26.5	7.16	7.26	22.46	17.84	4.62	21.96	3.336
1:37:19 PM	26.6	26.5	7.17	7.25	21.94	18.25	3.69	21.44	2.667
1:38:19 PM	26.6	26.5	7.17	7.28	21.94	17.03	4.91	21.44	3.546
1:39:19 PM	26.6	26.5	7.19	7.28	20.96	17.03	3.92	20.46	2.833
1:40:19 PM	26.6	26.5	7.20	7.30	20.48	16.27	4.21	19.98	3.042
1:41:19 PM	26.6	26.5	7.21	7.30	20.01	16.27	3.75	19.51	2.706
1:42:19 PM	26.6	26.5	7.22	7.32	19.56	15.54	4.02	19.06	2.905
1:43:19 PM	26.6	26.5	7.24	7.31	18.68	15.90	2.78	18.18	2.008
1:44:19 PM	26.6	26.5	7.24	7.35	18.68	14.50	4.18	18.18	3.019
1:45:19 PM	26.6	26.5	7.25	7.34	18.25	14.84	3.42	17.75	2.468
1:46:19 PM	26.6	26.5	7.26	7.36	17.84	14.17	3.67	17.34	2.650
1:47:19 PM	26.6	26.5	7.28	7.36	17.03	14.17	2.87	16.53	2.070
1:48:19 PM	26.6	26.5	7.28	7.38	17.03	13.53	3.50	16.53	2.530

20.3 cm air-lift_Trial 1_8/26/2008 (continued)

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		$C_t - C_{out}$	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
1:49:19 PM	26.6	26.5	7.30	7.39	16.27	13.22	3.04	15.77	2.199
1:50:19 PM	26.6	26.5	7.30	7.38	16.27	13.53	2.74	15.77	1.977
1:51:19 PM	26.6	26.5	7.31	7.42	15.90	12.34	3.56	15.40	2.569
1:52:19 PM	26.6	26.5	7.33	7.42	15.18	12.34	2.84	14.68	2.052
1:53:19 PM	26.6	26.5	7.34	7.43	14.84	12.06	2.78	14.34	2.006
1:54:19 PM	26.6	26.5	7.36	7.44	14.17	11.78	2.38	13.67	1.722
1:55:19 PM	26.6	26.5	7.37	7.45	13.85	11.52	2.33	13.35	1.682
1:56:19 PM	26.6	26.5	7.37	7.47	13.85	11.00	2.85	13.35	2.057
1:57:19 PM	26.6	26.5	7.38	7.46	13.53	11.25	2.28	13.03	1.644
1:58:19 PM	26.6	26.5	7.39	7.48	13.22	10.75	2.47	12.72	1.788
1:59:19 PM	26.6	26.5	7.41	7.49	12.63	10.50	2.12	12.13	1.534
2:00:19 PM	26.6	26.5	7.41	7.49	12.63	10.50	2.12	12.13	1.534
2:01:19 PM	26.6	26.5	7.43	7.50	12.06	10.26	1.80	11.56	1.297
2:02:19 PM	26.6	26.5	7.44	7.52	11.78	9.80	1.98	11.28	1.432
2:03:19 PM	26.6	26.5	7.45	7.53	11.52	9.58	1.94	11.02	1.399
2:04:19 PM	26.6	26.5	7.46	7.53	11.25	9.58	1.68	10.75	1.210
2:05:19 PM	26.6	26.5	7.47	7.54	11.00	9.36	1.64	10.50	1.183
2:06:19 PM	26.6	26.5	7.48	7.55	10.75	9.15	1.60	10.25	1.156
2:07:19 PM	26.6	26.5	7.49	7.56	10.50	8.94	1.56	10.00	1.129
2:08:19 PM	26.6	26.5	7.49	7.58	10.50	8.54	1.97	10.00	1.420
2:09:19 PM	26.6	26.5	7.51	7.59	10.03	8.34	1.69	9.53	1.219
2:10:19 PM	26.6	26.5	7.51	7.60	10.03	8.15	1.88	9.53	1.356
2:11:19 PM	26.6	26.5	7.53	7.60	9.58	8.15	1.43	9.08	1.030

20.3 cm air-lift_Trial 2_8/26/2008

Hydraulic and Alkalinity Summary

Time	Volume [liters]	Fill time [sec]	Q_L [l min^{-1}]	Alk [mg l^{-1}]
2:35 PM	20.06	2.42	497.36	156
3:00 PM	20.06	2.36	510.00	158
3:15 PM	20.06	2.5	481.44	157
3:45 PM	20.06	2.46	489.27	157

Lift	30	cm	$Q_{L,ave}$	494.52	l min^{-1}
C_s	0.5	mg l^{-1}	$Q_{G,ave}$	580.40	l min^{-1}
FW_{CO2}	44.01	g mol^{-1}	Q_G:Q_L	1.17	
V_{tank}	8436.9	liters	Alkalinity	157	mg $CaCO_3$ l^{-1}

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		C_t - C_{out}	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
2:30:29 PM	26.6	26.6	7.25	7.25	18.07	18.07	0.00	17.57	0.000
2:30:39 PM	26.6	26.6	7.27	7.22	17.25	19.36	-2.11	16.75	-1.499
2:30:49 PM	26.6	26.5	7.29	7.12	16.48	24.37	-7.89	15.98	-5.622
2:30:59 PM	26.6	26.6	7.29	6.85	16.48	45.39	-28.91	15.98	-20.585
2:31:09 PM	26.6	26.6	7.20	6.94	20.27	36.89	-16.62	19.77	-11.833
2:31:19 PM	26.6	26.6	7.12	6.94	24.37	36.89	-12.52	23.87	-8.914
2:31:30 PM	26.6	26.6	7.13	6.86	23.82	44.35	-20.53	23.32	-14.622
2:31:39 PM	26.6	26.6	7.01	6.89	31.40	41.39	-9.99	30.90	-7.116
2:31:49 PM	26.6	26.6	6.92	6.82	38.63	48.63	-10.00	38.13	-7.122
2:31:59 PM	26.6	26.6	6.99	6.78	32.88	53.32	-20.44	32.38	-14.558
2:32:10 PM	26.6	26.6	6.99	6.76	32.88	55.84	-22.96	32.38	-16.348
2:32:19 PM	26.6	26.6	6.92	6.83	38.63	47.52	-8.90	38.13	-6.334
2:32:29 PM	26.6	26.6	6.76	6.82	55.84	48.63	7.20	55.34	5.131
2:32:39 PM	26.6	26.6	6.77	6.79	54.56	52.11	2.46	54.06	1.749
2:32:49 PM	26.6	26.6	6.77	6.80	54.56	50.92	3.64	54.06	2.593
2:32:59 PM	26.6	26.6	6.77	6.80	54.56	50.92	3.64	54.06	2.593
2:33:09 PM	26.6	26.6	6.78	6.79	53.32	52.11	1.21	52.82	0.864
2:33:19 PM	26.6	26.6	6.79	6.80	52.11	50.92	1.19	51.61	0.845
2:33:29 PM	26.6	26.6	6.79	6.82	52.11	48.63	3.48	51.61	2.477
2:33:39 PM	26.6	26.6	6.79	6.81	52.11	49.76	2.35	51.61	1.670

20.3 cm air-lift_Trial 2_8/26/2008 (continued)

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		$C_t - C_{out}$	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
2:33:49 PM	26.6	26.6	6.78	6.82	53.32	48.63	4.69	52.82	3.341
2:33:59 PM	26.6	26.6	6.78	6.81	53.32	49.76	3.56	52.82	2.534
2:34:09 PM	26.6	26.6	6.78	6.82	53.32	48.63	4.69	52.82	3.341
2:34:19 PM	26.6	26.6	6.78	6.82	53.32	48.63	4.69	52.82	3.341
2:34:29 PM	26.6	26.6	6.79	6.82	52.11	48.63	3.48	51.61	2.477
2:34:39 PM	26.6	26.6	6.79	6.82	52.11	48.63	3.48	51.61	2.477
2:34:50 PM	26.6	26.6	6.78	6.84	53.32	46.44	6.88	52.82	4.900
2:34:59 PM	26.6	26.6	6.78	6.84	53.32	46.44	6.88	52.82	4.900
2:35:09 PM	26.6	26.6	6.78	6.83	53.32	47.52	5.80	52.82	4.129
2:35:19 PM	26.6	26.6	6.78	6.82	53.32	48.63	4.69	52.82	3.341
2:35:30 PM	26.6	26.6	6.79	6.84	52.11	46.44	5.67	51.61	4.035
2:35:39 PM	26.6	26.6	6.79	6.86	52.11	44.35	7.76	51.61	5.524
2:35:49 PM	26.6	26.6	6.79	6.84	52.11	46.44	5.67	51.61	4.035
2:36:00 PM	26.6	26.6	6.79	6.84	52.11	46.44	5.67	51.61	4.035
2:36:23 PM	26.6	26.6	6.79	6.84	52.11	46.44	5.67	51.61	4.035
2:37:23 PM	26.6	26.6	6.81	6.87	49.76	43.34	6.42	49.26	4.573
2:38:23 PM	26.6	26.6	6.83	6.88	47.52	42.36	5.17	47.02	3.680
2:39:23 PM	26.6	26.6	6.83	6.87	47.52	43.34	4.18	47.02	2.978
2:40:23 PM	26.6	26.6	6.83	6.90	47.52	40.45	7.07	47.02	5.038
2:41:23 PM	26.6	26.6	6.84	6.92	46.44	38.63	7.81	45.94	5.564
2:42:23 PM	26.6	26.6	6.84	6.92	46.44	38.63	7.81	45.94	5.564
2:43:23 PM	26.6	26.6	6.85	6.95	45.39	36.05	9.33	44.89	6.647
2:44:23 PM	26.6	26.6	6.87	6.95	43.34	36.05	7.29	42.84	5.192
2:45:23 PM	26.6	26.6	6.89	6.96	41.39	35.23	6.16	40.89	4.388
2:46:23 PM	26.6	26.6	6.91	6.98	39.53	33.64	5.88	39.03	4.190
2:47:23 PM	26.6	26.6	6.92	6.98	38.63	33.64	4.98	38.13	3.550
2:48:23 PM	26.6	26.6	6.93	7.00	37.75	32.13	5.62	37.25	4.002
2:49:23 PM	26.6	26.6	6.95	7.02	36.05	30.68	5.37	35.55	3.822
2:50:23 PM	26.6	26.6	6.97	7.03	34.43	29.99	4.44	33.93	3.164
2:51:23 PM	26.6	26.6	6.97	7.04	34.43	29.30	5.13	33.93	3.650
2:52:23 PM	26.6	26.6	7.00	7.06	32.13	27.98	4.15	31.63	2.952
2:53:23 PM	26.6	26.6	7.01	7.06	31.40	27.98	3.41	30.90	2.432
2:54:23 PM	26.6	26.6	7.03	7.08	29.99	26.72	3.26	29.49	2.322
2:55:23 PM	26.6	26.6	7.03	7.09	29.99	26.12	3.87	29.49	2.755
2:56:23 PM	26.6	26.6	7.05	7.12	28.64	24.37	4.26	28.14	3.036

20.3 cm air-lift_Trial 2_8/26/2008 (continued)

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		$C_t - C_{out}$	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
2:57:23 PM	26.6	26.6	7.06	7.12	27.98	24.37	3.61	27.48	2.571
2:58:23 PM	26.6	26.6	7.08	7.14	26.72	23.28	3.45	26.22	2.456
2:59:23 PM	26.6	26.6	7.09	7.16	26.12	22.23	3.89	25.62	2.768
3:00:23 PM	26.6	26.6	7.10	7.15	25.52	22.75	2.78	25.02	1.976
3:01:23 PM	26.6	26.6	7.11	7.16	24.94	22.23	2.71	24.44	1.931
3:02:23 PM	26.6	26.6	7.12	7.17	24.37	21.72	2.65	23.87	1.887
3:03:29 PM	26.6	26.6	7.13	7.18	23.82	21.23	2.59	23.32	1.845
3:04:29 PM	26.6	26.6	7.15	7.20	22.75	20.27	2.47	22.25	1.761
3:05:29 PM	26.6	26.6	7.16	7.22	22.23	19.36	2.87	21.73	2.043
3:06:29 PM	26.6	26.6	7.18	7.23	21.23	18.92	2.31	20.73	1.644
3:07:29 PM	26.6	26.6	7.19	7.24	20.75	18.49	2.26	20.25	1.607
3:08:29 PM	26.6	26.6	7.21	7.25	19.81	18.07	1.74	19.31	1.241
3:09:29 PM	26.6	26.6	7.21	7.27	19.81	17.25	2.56	19.31	1.820
3:10:29 PM	26.6	26.6	7.21	7.28	19.81	16.86	2.95	19.31	2.100
3:11:29 PM	26.6	26.6	7.23	7.29	18.92	16.48	2.44	18.42	1.738
3:12:29 PM	26.6	26.6	7.24	7.29	18.49	16.48	2.01	17.99	1.432
3:13:29 PM	26.6	26.6	7.25	7.31	18.07	15.74	2.33	17.57	1.660
3:14:29 PM	26.7	26.6	7.26	7.31	17.66	15.74	1.92	17.16	1.367
3:15:29 PM	26.7	26.6	7.28	7.33	16.86	15.03	1.83	16.36	1.306
3:16:29 PM	26.7	26.6	7.29	7.35	16.48	14.35	2.13	15.98	1.514
3:17:29 PM	26.7	26.6	7.29	7.36	16.48	14.03	2.45	15.98	1.747
3:18:29 PM	26.7	26.6	7.31	7.37	15.74	13.71	2.03	15.24	1.446
3:19:29 PM	26.7	26.6	7.32	7.38	15.38	13.39	1.98	14.88	1.413
3:20:29 PM	26.7	26.6	7.32	7.39	15.38	13.09	2.29	14.88	1.630
3:21:29 PM	26.7	26.6	7.34	7.39	14.69	13.09	1.60	14.19	1.137
3:22:29 PM	26.7	26.6	7.35	7.41	14.35	12.50	1.85	13.85	1.319
3:23:29 PM	26.7	26.6	7.36	7.41	14.03	12.50	1.53	13.53	1.086
3:24:29 PM	26.7	26.6	7.37	7.42	13.71	12.22	1.49	13.21	1.061
3:25:29 PM	26.7	26.6	7.38	7.43	13.39	11.94	1.46	12.89	1.037
3:26:29 PM	26.7	26.6	7.37	7.45	13.71	11.40	2.31	13.21	1.642
3:27:29 PM	26.7	26.6	7.39	7.46	13.09	11.14	1.95	12.59	1.388
3:28:29 PM	26.7	26.6	7.41	7.46	12.50	11.14	1.36	12.00	0.968
3:29:29 PM	26.7	26.6	7.42	7.47	12.22	10.89	1.33	11.72	0.946
3:30:29 PM	26.7	26.6	7.43	7.48	11.94	10.64	1.30	11.44	0.924
3:31:29 PM	26.7	26.6	7.44	7.50	11.67	10.16	1.51	11.17	1.072

20.3 cm air-lift_Trial 2_8/26/2008 (continued)

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		$C_t - C_{out}$	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
3:32:29 PM	26.7	26.6	7.45	7.50	11.40	10.16	1.24	10.90	0.883
3:33:29 PM	26.7	26.6	7.46	7.52	11.14	9.70	1.44	10.64	1.024
3:34:29 PM	26.7	26.6	7.47	7.53	10.89	9.48	1.40	10.39	1.000
3:35:29 PM	26.7	26.6	7.49	7.52	10.40	9.70	0.69	9.90	0.494
3:36:29 PM	26.7	26.6	7.48	7.54	10.64	9.27	1.37	10.14	0.978
3:37:29 PM	26.7	26.6	7.50	7.55	10.16	9.06	1.10	9.66	0.787
3:38:29 PM	26.7	26.6	7.50	7.56	10.16	8.85	1.31	9.66	0.934
3:39:29 PM	26.7	26.6	7.52	7.57	9.70	8.65	1.06	9.20	0.751
3:40:29 PM	26.7	26.6	7.53	7.58	9.48	8.45	1.03	8.98	0.734
3:41:29 PM	26.7	26.6	7.54	7.58	9.27	8.45	0.82	8.77	0.581
3:42:29 PM	26.7	26.6	7.54	7.60	9.27	8.07	1.20	8.77	0.851
3:43:29 PM	26.7	26.6	7.55	7.60	9.06	8.07	0.98	8.56	0.701

20.3 cm air-lift_Trial 3_8/26/2008

Hydraulic and Alkalinity Summary

Time	Volume [liters]	Fill time [sec]	Q_L [l min^{-1}]	Alk [mg l^{-1}]
4:05 PM	20.06	2.41	499.42	156
4:30 PM	20.06	2.44	493.28	157
5:00 PM	20.06	2.36	510.00	156
5:10 PM	20.06	2.32	518.79	154

Lift	30	cm	$Q_{L,ave}$	505.37	l min^{-1}
C_s	0.5	mg l^{-1}	$Q_{G,ave}$	580.40	l min^{-1}
FW_{CO2}	44.01	g mol^{-1}	Q_G:Q_L	1.15	
V_{tank}	8436.9	liters	Alkalinity	156	mg $CaCO_3$ l^{-1}

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		$C_t - C_{out}$	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
4:00:04 PM	26.7	26.7	7.55	7.55	8.98	8.98	0.00	8.48	0.000
4:00:15 PM	26.7	26.6	7.55	7.55	8.98	8.98	0.00	8.48	0.000

20.3 cm air-lift_Trial 3_8/26/2008 (continued)

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		$C_t - C_{out}$	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
4:00:24 PM	26.7	26.6	7.55	7.55	8.98	8.98	0.00	8.48	0.000
4:00:34 PM	26.7	26.7	7.31	7.55	15.61	8.98	6.63	15.11	4.823
4:00:44 PM	26.7	26.7	6.67	7.49	68.15	10.31	57.83	67.65	42.086
4:00:55 PM	26.7	26.6	6.47	7.48	108.00	10.55	97.45	107.50	70.918
4:01:04 PM	26.7	26.7	6.35	7.45	142.38	11.31	131.07	141.88	95.383
4:01:14 PM	26.7	26.7	6.30	7.40	159.75	12.69	147.06	159.25	107.022
4:01:24 PM	26.7	26.7	6.38	7.34	132.87	14.57	118.31	132.37	86.095
4:01:35 PM	26.7	26.7	6.45	7.29	113.09	16.35	96.75	112.59	70.407
4:01:44 PM	26.7	26.7	6.40	7.18	126.89	21.06	105.84	126.39	77.020
4:01:54 PM	26.7	26.7	6.39	6.99	129.85	32.62	97.23	129.35	70.760
4:02:04 PM	26.7	26.7	6.48	7.01	105.55	31.15	74.40	105.05	54.142
4:02:15 PM	26.7	26.7	6.63	7.04	74.72	29.07	45.65	74.22	33.222
4:02:24 PM	26.7	26.7	6.55	7.05	89.83	28.41	61.43	89.33	44.702
4:02:34 PM	26.7	26.7	6.55	7.02	89.83	30.44	59.39	89.33	43.224
4:02:44 PM	26.7	26.7	6.61	7.01	78.24	31.15	47.09	77.74	34.272
4:02:55 PM	26.7	26.7	6.69	6.89	65.08	41.06	24.02	64.58	17.478
4:03:04 PM	26.7	26.7	6.80	6.83	50.52	47.15	3.37	50.02	2.454
4:03:14 PM	26.7	26.7	6.80	6.79	50.52	51.69	-1.18	50.02	-0.856
4:03:25 PM	26.7	26.7	6.82	6.77	48.24	54.13	-5.89	47.74	-4.284
4:03:34 PM	26.7	26.7	6.81	6.81	49.37	49.37	0.00	48.87	0.000
4:03:44 PM	26.7	26.7	6.73	6.86	59.35	44.00	15.35	58.85	11.174
4:03:54 PM	26.7	26.7	6.70	6.87	63.60	43.00	20.60	63.10	14.992
4:04:05 PM	26.7	26.7	6.74	6.88	58.00	42.02	15.98	57.50	11.632
4:04:14 PM	26.7	26.7	6.83	6.89	47.15	41.06	6.08	46.65	4.427
4:04:24 PM	26.7	26.7	6.96	6.92	34.95	38.32	-3.37	34.45	-2.454
4:04:35 PM	26.7	26.7	6.86	6.93	44.00	37.45	6.55	43.50	4.767
4:04:44 PM	26.7	26.7	6.81	6.89	49.37	41.06	8.31	48.87	6.044
4:04:54 PM	26.7	26.7	6.83	6.88	47.15	42.02	5.13	46.65	3.731
4:05:05 PM	26.7	26.7	6.86	6.87	44.00	43.00	1.00	43.50	0.729
4:05:14 PM	26.7	26.7	6.90	6.91	40.13	39.21	0.91	39.63	0.665
4:05:24 PM	26.7	26.7	6.87	6.92	43.00	38.32	4.68	42.50	3.403
4:05:35 PM	26.7	26.7	6.85	6.89	45.02	41.06	3.96	44.52	2.883
4:05:44 PM	26.7	26.7	6.85	6.88	45.02	42.02	3.01	44.52	2.187
4:05:54 PM	26.7	26.7	6.86	6.87	44.00	43.00	1.00	43.50	0.729
4:06:05 PM	26.7	26.7	6.88	6.93	42.02	37.45	4.57	41.52	3.325

20.3 cm air-lift_Trial 3_8/26/2008 (continued)

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		$C_t - C_{out}$	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
4:06:14 PM	26.7	26.7	6.86	6.92	44.00	38.32	5.68	43.50	4.132
4:06:24 PM	26.7	26.7	6.84	6.90	46.07	40.13	5.95	45.57	4.326
4:06:35 PM	26.7	26.7	6.87	6.90	43.00	40.13	2.87	42.50	2.089
4:06:44 PM	26.7	26.7	6.88	6.94	42.02	36.60	5.42	41.52	3.946
4:06:54 PM	26.7	26.7	6.87	6.92	43.00	38.32	4.68	42.50	3.403
4:07:04 PM	26.7	26.7	6.87	6.91	43.00	39.21	3.78	42.50	2.753
4:07:14 PM	26.7	26.7	6.87	6.91	43.00	39.21	3.78	42.50	2.753
4:07:25 PM	26.7	26.7	6.87	6.92	43.00	38.32	4.68	42.50	3.403
4:07:35 PM	26.7	26.7	6.87	6.92	43.00	38.32	4.68	42.50	3.403
4:07:52 PM	26.7	26.7	6.87	6.93	43.00	37.45	5.55	42.50	4.038
4:08:51 PM	26.7	26.7	6.88	6.94	42.02	36.60	5.42	41.52	3.946
4:09:51 PM	26.7	26.7	6.89	6.94	41.06	36.60	4.47	40.56	3.250
4:10:51 PM	26.7	26.7	6.89	6.96	41.06	34.95	6.11	40.56	4.448
4:11:51 PM	26.7	26.7	6.91	6.98	39.21	33.38	5.84	38.71	4.248
4:12:51 PM	26.7	26.7	6.92	7.01	38.32	31.15	7.17	37.82	5.220
4:13:51 PM	26.7	26.7	6.93	7.00	37.45	31.87	5.57	36.95	4.057
4:14:51 PM	26.7	26.7	6.95	7.03	35.76	29.75	6.02	35.26	4.379
4:15:51 PM	26.7	26.7	6.96	7.03	34.95	29.75	5.20	34.45	3.786
4:16:51 PM	26.7	26.7	6.97	7.05	34.15	28.41	5.75	33.65	4.182
4:17:51 PM	26.7	26.7	6.98	7.05	33.38	28.41	4.97	32.88	3.616
4:18:51 PM	26.7	26.7	7.00	7.08	31.87	26.51	5.36	31.37	3.902
4:19:51 PM	26.7	26.7	7.01	7.09	31.15	25.91	5.24	30.65	3.814
4:20:51 PM	26.7	26.7	7.03	7.09	29.75	25.91	3.84	29.25	2.793
4:21:51 PM	26.7	26.7	7.05	7.10	28.41	25.32	3.09	27.91	2.248
4:22:51 PM	26.7	26.7	7.06	7.10	27.76	25.32	2.44	27.26	1.778
4:23:51 PM	26.7	26.7	7.07	7.14	27.13	23.09	4.04	26.63	2.939
4:24:51 PM	26.7	26.7	7.07	7.16	27.13	22.05	5.08	26.63	3.695
4:25:51 PM	26.7	26.7	7.09	7.16	25.91	22.05	3.86	25.41	2.807
4:26:51 PM	26.7	26.7	7.10	7.17	25.32	21.55	3.77	24.82	2.743
4:27:51 PM	26.7	26.7	7.11	7.19	24.74	20.58	4.16	24.24	3.029
4:28:51 PM	26.7	26.7	7.12	7.20	24.18	20.11	4.07	23.68	2.960
4:29:51 PM	26.7	26.7	7.13	7.22	23.63	19.21	4.42	23.13	3.218
4:30:51 PM	26.7	26.7	7.14	7.20	23.09	20.11	2.98	22.59	2.168
4:31:51 PM	26.7	26.7	7.15	7.23	22.57	18.77	3.80	22.07	2.763
4:32:51 PM	26.7	26.7	7.16	7.23	22.05	18.77	3.28	21.55	2.389

20.3 cm air-lift_Trial 3_8/26/2008 (continued)

	Temperature [°C]		pH		Carbon Dioxide [mg l^{-1}]		$C_t - C_{out}$	$C_{deficit}$	CTR
Time	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	[mg l^{-1}]	[mg l^{-1}]	[kg CO_2 day^{-1}]
4:33:51 PM	26.7	26.7	7.17	7.26	21.55	17.52	4.03	21.05	2.935
4:34:51 PM	26.7	26.7	7.18	7.26	21.06	17.52	3.54	20.56	2.578
4:35:51 PM	26.7	26.7	7.19	7.28	20.58	16.73	3.85	20.08	2.803
4:36:51 PM	26.7	26.7	7.20	7.29	20.11	16.35	3.76	19.61	2.739
4:37:51 PM	26.7	26.7	7.22	7.30	19.21	15.98	3.23	18.71	2.351
4:38:51 PM	26.7	26.7	7.23	7.31	18.77	15.61	3.16	18.27	2.298
4:39:51 PM	26.7	26.7	7.23	7.32	18.77	15.26	3.51	18.27	2.557
4:40:51 PM	26.8	26.7	7.25	7.33	17.92	14.91	3.02	17.42	2.195
4:41:51 PM	26.8	26.7	7.26	7.33	17.52	14.91	2.61	17.02	1.898
4:42:51 PM	26.8	26.7	7.27	7.35	17.12	14.24	2.88	16.62	2.096
4:43:51 PM	26.8	26.7	7.30	7.36	15.98	13.91	2.06	15.48	1.500
4:44:51 PM	26.8	26.7	7.31	7.38	15.61	13.29	2.32	15.11	1.691
4:45:51 PM	26.8	26.7	7.31	7.39	15.61	12.99	2.63	15.11	1.911
4:46:51 PM	26.8	26.7	7.32	7.42	15.26	12.12	3.14	14.76	2.283
4:47:51 PM	26.8	26.7	7.33	7.41	14.91	12.40	2.51	14.41	1.825
4:48:51 PM	26.8	26.7	7.34	7.43	14.57	11.84	2.73	14.07	1.985
4:49:51 PM	26.8	26.7	7.35	7.42	14.24	12.12	2.12	13.74	1.542
4:50:51 PM	26.8	26.7	7.36	7.45	13.91	11.31	2.60	13.41	1.895
4:51:51 PM	26.8	26.7	7.37	7.44	13.60	11.57	2.02	13.10	1.473
4:52:51 PM	26.8	26.7	7.38	7.46	13.29	11.05	2.24	12.79	1.627
4:53:51 PM	26.8	26.7	7.39	7.47	12.99	10.80	2.18	12.49	1.590
4:54:51 PM	26.8	26.7	7.39	7.49	12.99	10.31	2.67	12.49	1.944
4:55:51 PM	26.8	26.7	7.40	7.50	12.69	10.08	2.61	12.19	1.899
4:56:51 PM	26.8	26.7	7.42	7.50	12.12	10.08	2.04	11.62	1.484
4:57:51 PM	26.8	26.7	7.43	7.52	11.84	9.63	2.22	11.34	1.613
4:58:51 PM	26.8	26.7	7.45	7.53	11.31	9.41	1.90	10.81	1.385
4:59:51 PM	26.8	26.7	7.45	7.53	11.31	9.41	1.90	10.81	1.385
5:00:51 PM	26.8	26.7	7.46	7.54	11.05	9.19	1.86	10.55	1.353
5:01:51 PM	26.8	26.7	7.47	7.55	10.80	8.98	1.82	10.30	1.322
5:02:51 PM	26.8	26.7	7.48	7.56	10.55	8.78	1.78	10.05	1.292
5:03:51 PM	26.8	26.7	7.49	7.57	10.31	8.58	1.74	9.81	1.263
5:04:51 PM	26.8	26.7	7.50	7.57	10.08	8.58	1.50	9.58	1.092
5:05:51 PM	26.8	26.7	7.50	7.59	10.08	8.19	1.89	9.58	1.373
5:06:51 PM	26.8	26.7	7.51	7.60	9.85	8.01	1.84	9.35	1.342
5:07:51 PM	26.8	26.7	7.52	7.61	9.63	7.82	1.80	9.13	1.311

pH/Alkalinity CTR and $C_{deficit}$ Linear Regression Summary for 580 l min^{-1} air injection

Air-lift [cm]	Trial	Lift [cm]	CTR Coefficient for $C_{deficit}$ equations	R^2
20.3	1	30	$CTR = 0.1462*C_{deficit}$	0.958
20.3	2	30	$CTR = 0.0912*C_{deficit}$	0.902
20.3	3	30	$CTR = 0.1185*C_{deficit}$	0.864

pH/Alkalinity K_La and SCTR Summary for 580 l min^{-1} air injection

		K_La [min^{-1}]		K_La_{20} [min^{-1}]		SCTR [kg hr^{-1}]	
Air-lift [cm]	**Trial**	**Inlet**	**Outlet**	**Inlet**	**Outlet**	**Inlet**	**Outlet**
20.3	1	0.026	0.025	0.022	0.022	0.0056	0.0054
20.3	2	0.027	0.027	0.023	0.023	0.0059	0.0058
20.3	3	0.026	0.027	0.022	0.023	0.0057	0.0059
	Ave	**0.027**	**0.026**	**0.023**	**0.023**	**0.0057**	**0.0057**
	St. D.	**0.001**	**0.001**	**0.001**	**0.001**	**0.0002**	**0.0003**

DEGASSING STUDIES_Head Space Method

10.2 cm air-lift_170 l air min^{-1}

10.2 cm air-lift_Trial 1_8/2/2007

Hydraulic Summary

Time	Volume [liters]	Fill time [sec]	Q_L [l min^{-1}]
8:30 AM	20.06	7.32	164.43
9:00 AM	20.06	7.25	166.01
10:00 AM	20.06	7.4	162.65
11:00 AM	20.06	7.5	160.48

Lift	30.5	cm	$Q_{L,ave}$	163.39	l min^{-1}
C_s	0.5	mg l^{-1}	$Q_{G,ave}$	170.00	l min^{-1}
FW_{CO2}	44.01	g mol^{-1}	Q_G:Q_L	1.04	
V_{tank}	7231.60	liters			

	Temp.	Barometric Pressure	CO_2	P_{CO2}	Salinity	B_{CO2}	DCO_2
Time	[°C]	[mm Hg]	[%]		[ppt]	Outlet	[mg l^{-1}]
8:30 AM	25.2	761.7	6.42	48.90	1.15	0.75	98.78
8:40 AM	25.2	761.9	6.12	46.63	1.15	0.75	94.18
8:50 AM	25.2	762.0	5.94	45.26	1.15	0.75	91.43
9:05 AM	25.2	762.0	5.00	38.10	1.15	0.75	76.96
9:20 AM	25.2	762.7	4.34	33.10	1.15	0.75	66.86
9:35 AM	25.2	762.7	3.52	26.85	1.15	0.75	54.23
9:50 AM	25.2	762.8	3.00	22.88	1.15	0.75	46.22
10:05 AM	25.2	762.8	2.46	18.76	1.15	0.75	37.90
10:20 AM	25.3	763.2	2.00	15.26	1.15	0.74	30.75
10:35 AM	25.3	763.3	1.68	12.82	1.15	0.74	25.83
10:50 AM	25.3	763.5	1.32	10.08	1.15	0.74	20.30
11:05 AM	25.3	763.5	1.06	8.09	1.15	0.74	16.30
11:20 AM	25.3	763.3	0.90	6.87	1.15	0.74	13.84
11:35 AM	25.4	763.4	0.78	5.95	1.15	0.74	11.96
11:50 AM	25.4	763.5	0.62	4.73	1.15	0.74	9.51
12:05 PM	25.4	763.5	0.56	4.28	1.15	0.74	8.59

10.2 cm air-lift_Trial 2_8/3/2007

Hydraulic Summary

Time	Volume [liters]	Fill time [sec]	Q_L [l min^{-1}]
9:00 AM	20.06	7.37	163.31
10:00 AM	20.06	7.59	158.58
11:00 AM	20.06	7.34	163.98
11:30 AM	20.06	7.38	163.09

Lift	30.5	cm	$Q_{L,ave}$	162.24	l min^{-1}
C_s	0.5	mg l^{-1}	$Q_{G,ave}$	170.00	l min^{-1}
FW_{CO2}	44.01	g mol^{-1}	Q_G:Q_L	1.05	
V_{tank}	7231.60	liters			

Time	Temp. [°C]	Barometric Pressure [mm Hg]	CO_2 [%]	P_{CO2}	Salinity [ppt]	B_{CO2} Outlet	DCO_2 [mg l^{-1}]
8:52 AM	25.2	762.2	8.18	62.35	1.15	0.75	126.33
9:02 AM	25.2	762.2	7.60	57.93	1.15	0.75	117.37
9:17 AM	25.2	762.6	6.40	48.81	1.15	0.75	98.89
9:32 AM	25.2	762.6	5.90	44.99	1.15	0.75	91.17
9:47 AM	25.2	762.8	4.70	35.85	1.15	0.75	72.64
10:02 AM	25.2	762.8	3.84	29.29	1.15	0.75	59.35
10:17 AM	25.3	763.2	3.26	24.88	1.15	0.75	50.28
10:32 AM	25.3	763.3	2.50	19.08	1.15	0.75	38.56
10:47 AM	25.3	763.5	2.30	17.56	1.15	0.75	35.49
11:02 AM	25.3	763.5	2.00	15.27	1.15	0.75	30.86
11:17 AM	25.3	763.3	1.50	11.45	1.15	0.75	23.14
11:32 AM	25.4	763.4	1.26	9.62	1.15	0.74	19.39
11:47 AM	25.4	763.5	1.02	7.79	1.15	0.74	15.70
12:02 PM	25.4	763.5	0.80	6.11	1.15	0.74	12.31
12:17 PM	25.4	763.6	0.67	5.12	1.15	0.74	10.31
12:32 PM	25.4	763.6	0.54	4.12	1.15	0.74	8.31

10.2 cm air-lift_Trial 3_8/3/2007

Hydraulic Summary

Time	Volume [liters]	Fill time [sec]	Q_L [l min^{-1}]
1:45 PM	20.06	7.25	166.01
2:30 PM	20.06	7.51	160.27
4:00 PM	20.06	7.41	162.43
5:00 PM	20.06	7.45	161.56

Lift	30.5	cm	$Q_{L,ave}$	162.57	l min^{-1}
C_s	0.5	mg l^{-1}	$Q_{G,ave}$	170.00	l min^{-1}
FW_{CO2}	44.01	g mol^{-1}	Q_G:Q_L	1.05	
V_{tank}	7231.60	liters			

Time	Temp. [°C]	Barometric Pressure [mm Hg]	CO_2 [%]	P_{CO2}	Salinity [ppt]	B_{CO2} Outlet	DCO_2 [mg l^{-1}]
1:40 PM	25.6	763.8	6.18	47.20	1.15	0.74	94.62
1:50 PM	25.6	763.7	5.12	39.10	1.15	0.74	78.38
2:05 PM	25.6	763.7	4.72	36.05	1.15	0.74	72.26
2:20 PM	25.7	763.8	4.38	33.45	1.15	0.74	66.89
2:35 PM	25.7	764.0	3.46	26.43	1.15	0.74	52.85
2:50 PM	25.7	764.3	3.12	23.85	1.15	0.74	47.68
3:05 PM	25.7	763.7	2.30	17.57	1.15	0.74	35.12
3:20 PM	25.7	763.4	2.02	15.42	1.15	0.74	30.83
3:35 PM	25.7	763.5	1.72	13.13	1.15	0.74	26.26
3:50 PM	25.7	763.4	1.40	10.69	1.15	0.74	21.37
4:05 PM	25.7	763.2	1.20	9.16	1.15	0.74	18.31
4:20 PM	25.7	763.2	0.96	7.33	1.15	0.74	14.65
4:35 PM	25.7	763.2	0.78	5.95	1.15	0.74	11.90
4:50 PM	25.7	763.2	0.67	5.11	1.15	0.74	10.22
5:05 PM	25.7	763.3	0.58	4.43	1.15	0.74	8.85
5:20 PM	25.7	763.2	0.50	3.82	1.15	0.74	7.63

Head Space K_La and SCTR Summary for 170 l min^{-1} air injection

Air-lift [cm]	Trial	K_La [min^{-1}]	K_La_{20} [min^{-1}]	SCTR [kg hr^{-1}]
10.2	1	0.013	0.012	0.0025
10.2	2	0.013	0.011	0.0025
10.2	3	0.012	0.011	0.0024
	Ave	**0.013**	**0.011**	**0.0025**
	St. D.	**0.000**	**0.000**	**0.0001**

DEGASSING STUDIES_Head Space Method (continued)

15.2 cm air-lift_340 l air min^{-1}

15.2 cm air-lift_Trial 1_8/1/2007

Hydraulic Summary

Time	Volume [liters]	Fill time [sec]	Q_L [l min^{-1}]
8:15 AM	20.06	3.47	346.86
9:00 AM	20.06	3.5	343.89
9:30 AM	20.06	3.6	334.33
10:00 AM	20.06	3.53	340.96

Lift	30.5	cm	$Q_{L,ave}$	341.51	l min^{-1}
C_s	0.5	mg l^{-1}	$Q_{G,ave}$	340.00	l min^{-1}
FW_{CO2}	44.01	g mol^{-1}	Q_G:Q_L	1.00	
V_{tank}	7231.60	liters			

	Temp.	Barometric Pressure	CO_2	P_{CO2}	Salinity	B_{CO2}	DCO_2
Time	[°C]	[mm Hg]	[%]		[ppt]	Outlet	[mg l^{-1}]
8:15 AM	25.6	760.1	6.02	45.76	1.13	0.74	91.74
8:25 AM	25.6	760.1	5.43	41.27	1.13	0.74	82.75
8:35 AM	25.6	760.2	4.60	34.97	1.13	0.74	70.11
8:45 AM	25.6	760.3	3.96	30.11	1.13	0.74	60.36
8:55 AM	25.6	760.3	3.40	25.85	1.13	0.74	51.83
9:05 AM	25.6	760.4	2.50	19.01	1.13	0.74	38.11
9:15 AM	25.6	760.6	1.80	13.69	1.13	0.74	27.45
9:25 AM	25.6	760.6	1.30	9.89	1.13	0.74	19.82
9:35 AM	25.6	760.8	1.10	8.37	1.13	0.74	16.78
9:45 AM	25.6	760.8	0.80	6.09	1.13	0.74	12.20
9:55 AM	25.6	760.8	0.69	5.25	1.13	0.74	10.52
10:05 AM	25.6	760.8	0.56	4.26	1.13	0.74	8.54

15.2 cm air-lift_Trial 2_8/1/2007

Hydraulic Summary

Time	Volume [liters]	Fill time [sec]	Q_L [l min^{-1}]
10:30 AM	20.06	3.51	342.91
11:00 AM	20.06	3.44	349.88
11:30 AM	20.06	3.55	339.04
12:00 AM	20.06	3.37	357.15

Lift	30.5	cm	$Q_{L,ave}$	347.25	l min^{-1}
C_s	0.5	mg l^{-1}	$Q_{G,ave}$	340.00	l min^{-1}
FW_{CO2}	44.01	g mol^{-1}	Q_G:Q_L	0.98	
V_{tank}	7231.60	liters			

Time	Temp. [°C]	Barometric Pressure [mm Hg]	CO_2 [%]	P_{CO2}	Salinity [ppt]	B_{CO2} Outlet	DCO_2 [mg l^{-1}]
10:20 AM	25.6	761.0	6.80	51.75	1.13	0.74	103.75
10:30 AM	25.6	761.1	6.18	47.04	1.13	0.74	94.30
10:40 AM	25.6	761.1	4.82	36.69	1.13	0.74	73.55
10:50 AM	25.6	761.2	3.88	29.53	1.13	0.74	59.21
11:00 AM	25.6	761.3	3.00	22.84	1.13	0.74	45.79
11:10 AM	25.6	761.2	2.30	17.51	1.13	0.74	35.10
11:20 AM	25.6	761.5	1.82	13.86	1.13	0.74	27.79
11:30 AM	25.6	761.4	1.48	11.27	1.13	0.74	22.59
11:40 AM	25.6	761.4	1.26	9.59	1.13	0.74	19.23
11:50 AM	25.7	761.4	0.86	6.55	1.13	0.74	13.09
12:00 PM	25.7	761.4	0.65	4.95	1.13	0.74	9.90
12:10 PM	25.7	761.4	0.57	4.34	1.13	0.74	8.68
12:20 PM	25.7	761.5	0.51	3.88	1.13	0.74	7.77

15.2 cm air-lift_Trial 3_8/1/2007

Hydraulic Summary

Time	Volume [liters]	Fill time [sec]	Q_L [l min^{-1}]
2:30 PM	20.06	3.60	334.33
3:00 PM	20.06	3.45	348.87
3:30 PM	20.06	3.53	340.96
4:00 PM	20.06	3.6	334.33

Lift	30.5	cm	$Q_{L,ave}$	339.62	l min^{-1}
C_s	0.5	mg l^{-1}	$Q_{G,ave}$	340.00	l min^{-1}
FW_{CO2}	44.01	g mol^{-1}	Q_G:Q_L	1.00	
V_{tank}	7231.60	liters			

Time	Temp. [°C]	Barometric Pressure [mm Hg]	CO_2 [%]	P_{CO2}	Salinity [ppt]	B_{CO2} Outlet	DCO_2 [mg l^{-1}]
2:20 PM	25.7	760.3	5.78	43.95	1.13	0.74	87.87
2:30 PM	25.7	760.3	4.96	37.71	1.13	0.74	75.40
2:40 PM	25.7	760.3	4.16	31.63	1.13	0.74	63.24
2:50 PM	25.7	760.1	3.54	26.91	1.13	0.74	53.80
3:00 PM	25.7	760.4	2.98	22.66	1.13	0.74	45.31
3:10 PM	25.7	760.6	2.34	17.80	1.13	0.74	35.59
3:20 PM	25.7	760.6	1.62	12.32	1.13	0.74	24.64
3:30 PM	25.6	760.9	1.32	10.04	1.13	0.74	20.14
3:40 PM	25.6	760.5	1.15	8.75	1.13	0.74	17.53
3:50 PM	25.6	760.5	0.88	6.69	1.13	0.74	13.42
4:00 PM	25.6	760.3	0.68	5.17	1.13	0.74	10.37
4:10 PM	25.6	760.3	0.52	3.95	1.13	0.74	7.93

Head Space K_La and SCTR Summary for 340 l min^{-1} air injection

Air-lift [cm]	Trial	K_La [min^{-1}]	K_La_{20} [min^{-1}]	SCTR [kg hr^{-1}]
15.2	1	0.026	0.023	0.0049
15.2	2	0.025	0.022	0.0048
15.2	3	0.024	0.021	0.0045
	Ave	**0.025**	**0.022**	**0.0047**
	St. D.	**0.001**	**0.001**	**0.0002**

DEGASSING STUDIES_Head Space Method (continued)

20.3 cm air-lift_580 l air min^{-1}

20.3 cm air-lift_Trial 1_7/30/2007

Hydraulic Summary

Time	Volume [liters]	Fill time [sec]	Q_L [l min^{-1}]
5:00 PM	20.06	2.48	485.32
5:30 PM	20.06	2.47	487.29
6:00 PM	20.06	2.45	491.27
6:30 PM	20.06	2.38	505.71

Lift	30	cm	$Q_{L,ave}$	492.40	l min^{-1}
C_s	0.5	mg l^{-1}	$Q_{G,ave}$	580.00	l min^{-1}
FW_{CO2}	44.01	g mol^{-1}	Q_G:Q_L	1.18	
V_{tank}	8436.87	liters			

Time	Temp. [°C]	Barometric Pressure [mm Hg]	CO_2 [%]	P_{CO2}	Salinity [ppt]	B_{CO2} Outlet	DCO_2 [mg l^{-1}]
4:55 PM	25.8	761.0	6.10	46.42	1.12	0.74	92.58
5:05 PM	25.8	761.3	5.78	44.00	1.12	0.74	87.75
5:15 PM	25.8	761.4	4.42	33.65	1.12	0.74	67.12
5:25 PM	25.8	761.2	3.62	27.56	1.12	0.74	54.95
5:35 PM	25.8	761.2	2.70	20.55	1.12	0.74	40.99
5:45 PM	25.8	761.2	1.85	14.08	1.12	0.74	28.08
5:55 PM	25.8	761.1	1.24	9.44	1.12	0.74	18.82
6:05 PM	25.8	761.0	0.92	7.00	1.12	0.74	13.96
6:15 PM	25.8	761.0	0.70	5.33	1.12	0.74	10.62
6:25 PM	25.8	761.2	0.55	4.19	1.12	0.74	8.35

15.2 cm air-lift_Trial 2_7/31/2007

Hydraulic Summary

Time	Volume [liters]	Fill time [sec]	Q_L [l min^{-1}]
9:30 AM	20.06	2.41	499.42
10:00 AM	20.06	2.38	505.71
10:30 AM	20.06	2.29	525.59
11:00 AM	20.06	2.47	487.29

Lift	**30**	**cm**	$Q_{L,ave}$	**504.50**	**l min^{-1}**
C_s	**0.5**	**mg l^{-1}**	$Q_{G,ave}$	**580.00**	**l min^{-1}**
FW_{CO2}	**44.01**	**g mol^{-1}**	$Q_G:Q_L$	**1.15**	
V_{tank}	**8436.87**	**liters**			

	Temp.	Barometric Pressure	CO_2	P_{CO2}	Salinity	B_{CO2}	DCO_2
Time	[°C]	[mm Hg]	[%]		[ppt]	Outlet	[mg l^{-1}]
9:35 AM	25.8	761.5	4.90	37.31	1.12	0.74	74.41
9:45 AM	25.8	761.6	4.20	31.99	1.12	0.74	63.79
9:55 AM	25.8	761.7	3.50	26.66	1.12	0.74	53.17
10:05 AM	25.8	761.7	2.68	20.41	1.12	0.74	40.71
10:15 AM	25.8	761.8	1.76	13.41	1.12	0.74	26.74
10:25 AM	25.8	761.9	1.38	10.51	1.12	0.74	20.97
10:35 AM	25.9	762.0	0.88	6.71	1.12	0.73	13.34
10:45 AM	25.9	762.0	0.68	5.18	1.12	0.73	10.31
10:55 AM	25.9	762.0	0.58	4.42	1.12	0.73	8.79
11:05 AM	25.9	762.0	0.44	3.35	1.12	0.73	6.67

15.2 cm air-lift_Trial 3_8/1/2007

Hydraulic Summary

Time	Volume [liters]	Fill time [sec]	Q_L [l min^{-1}]
2:15 PM	20.06	2.43	495.31
2:30 PM	20.06	2.47	487.29
3:00 PM	20.06	2.34	514.36
3:30 PM	20.06	2.4	501.50

Lift	**30**	**cm**	$Q_{L,ave}$	**499.61**	**l min^{-1}**
C_s	**0.5**	**mg l^{-1}**	$Q_{G,ave}$	**580.00**	**l min^{-1}**
FW_{CO2}	**44.01**	**g mol^{-1}**	$Q_G:Q_L$	**1.16**	
V_{tank}	**8436.87**	**liters**			

Time	Temp. [°C]	Barometric Pressure [mm Hg]	CO_2 [%]	P_{CO2}	Salinity [ppt]	B_{CO2} Outlet	DCO_2 [mg l^{-1}]
2:10 PM	25.9	760.9	6.40	48.70	1.13	0.73	96.84
2:20 PM	25.9	761.0	5.72	43.53	1.13	0.73	86.56
2:30 PM	25.9	760.8	4.10	31.19	1.13	0.73	62.03
2:40 PM	25.9	760.8	3.38	25.72	1.13	0.73	51.14
2:50 PM	25.9	760.8	2.10	15.98	1.13	0.73	31.77
3:00 PM	25.9	760.6	1.70	12.93	1.13	0.73	25.71
3:10 PM	25.9	760.3	1.10	8.36	1.13	0.73	16.63
3:20 PM	25.9	760.4	0.86	6.54	1.13	0.73	13.00
3:30 PM	25.9	760.3	0.61	4.64	1.13	0.73	9.22
3:40 PM	25.9	760.6	0.45	3.42	1.13	0.73	6.81

Head Space K_La and SCTR Summary for 580 l min^{-1} air injection

Air-lift [cm]	Trial	K_La [min^{-1}]	K_La_{20} [min^{-1}]	SCTR [kg hr^{-1}]
15.2	1	0.032	0.028	0.0061
15.2	2	0.031	0.027	0.0059
15.2	3	0.033	0.029	0.0063
	Ave	**0.032**	**0.028**	**0.0061**
	St. D.	**0.001**	**0.001**	**0.0002**

APPENDIX C:
STEADY STATE MASS BALANCE DERIVATIONS

OXYGEN DERIVATIONS

The general mass balance equations for determining $C_{tank,O2}$ and $C_{b,O2}$ based on the representation in Figure 4-1.

1. $$\frac{dC_{\tan k,O_2}V}{dt} = -R_{C1} - R_{fish} + R_{airlift} + R_{C2}$$

$$\frac{dC_{\tan k,O_2}V}{dt} = -0.00144\,Q_L C_{\tan k} - F(K_{fish,O2}) + K_{air,O2}(C_s - C_b)Q_G + 0.00144\,Q_L C_b$$

2. $$\frac{dC_{b,O_2}V}{dt} = R_{C1} - R_{bacteria} - R_{C2}$$

$$\frac{dC_{b,O_2}V}{dt} = 0.00144\,Q_L C_{\tan k} - F(K_{bac,O2}) - 0.00144\,Q_L C_b$$

OXYGEN DERIVATIONS (continued)

Part 1. Assuming steady state conditions, $dC_{b,O2}V\ dt^{-1} = 0$, equation 2 was solved for $C_{b,O2}$:

$$0 = 0.00144\,Q_L\,C_{\tan k} - F\,(K_{bac,O2}) - 0.00144\,Q_L\,C_b$$

$$\boxed{C_{b,O2} = C_{\tan k} - \frac{F\,(K_{bac,O2})}{0.00144\,Q_L}}$$

Part 2. The resulting equation for $C_{b,O2}$ was inserted into equation 1 and allowed $C_{tank,O2}$ to be solved as follows:

$$0 = -0.00144\,Q_L\,C_{\tan k} - F\,(K_{fish,O2}) + K_{air,O2}\left[C_s - C_{\tan k} + \frac{F\,(K_{bac,O2})}{0.00144\,Q_L}\right]Q_G + 0.00144\,Q_L\left[C_{\tan k} - \frac{F\,(K_{bac,O2})}{0.00144\,Q_L}\right]$$

$$\boxed{C_{\tan k,O_2} = -F\left(\frac{K_{bac,O_2} + K_{fish,O_2}}{K_{air,O_2} * Q_G} - \frac{K_{bac,O_2}}{0.00144\,Q_L}\right) + C_s}$$

CARBON DIOXIDE DERIVATIONS

The general mass balance equations for determining $C_{tank,CO2}$ and $C_{b,CO2}$ based on the representation in Figure 4-1.

1. $$\frac{dC_{\tan k,CO_2}V}{dt} = -R_{C1} + R_{fish} - R_{airlift} + R_{C2}$$

$$\frac{dC_{\tan k,CO_2}V}{dt} = -0.00144\,Q_L C_{\tan k} + F(K_{fish,CO2}) - K_{air,CO2}(C_b - C_s)Q_G + 0.00144\,Q_L C_b$$

2. $$\frac{dC_{b,CO_2}V}{dt} = R_{C1} + R_{bacteria} - R_{C2}$$

$$\frac{dC_{b,CO_2}V}{dt} = 0.00144\,Q_L C_{\tan k} + F(K_{bac,CO2}) - 0.00144\,Q_L C_b$$

CARBON DIOXIDE DERIVATIONS (continued)

Part 1. Assuming steady state conditions, $dC_{b,CO2}V\ dt^{-1} = 0$, equation 2 was solved for $C_{b,CO2}$:

$$0 = 0.00144\,Q_L\,C_{\tan k} + F\,(K_{bac,CO2}) - 0.00144\,Q_L\,C_b$$

$$C_{b,CO2} = C_{\tan k} + \frac{F\,(K_{bac,CO2})}{0.00144\,Q_L}$$

Part 2. The resulting equation for $C_{b,CO2}$ was inserted into equation 1 and allowed $C_{tank,CO2}$ to be solved as follows:

$$0 = -0.00144\,Q_L\,C_{\tan k} + F\,(K_{fish,CO2}) - K_{air,CO2}\left[C_{\tan k} + \frac{F\,(K_{bac,CO2})}{0.00144\,Q_L} - C_s\right]Q_G + 0.00144\,Q_L\left[C_{\tan k} + \frac{F\,(K_{bac,CO2})}{0.00144\,Q_L}\right]$$

$$C_{\tan k,O_2} = F\left(\frac{K_{bac,CO_2} + K_{fish,CO_2}}{K_{air,CO_2} * Q_G} - \frac{K_{bac,CO_2}}{0.00144\,Q_L}\right) + C_s$$

VITA

Ryan Anthony Hearn was born in October 1982, in Vicksburg, Mississippi, and is the middle child to James E. and Barbara B. Hearn. He graduated from Vicksburg Catholic School with honors and soon enrolled in Hinds Junior College in Raymond, Mississippi, on an athletic and academic scholarship. After two years of playing baseball for the Eagles, Ryan transferred to Louisiana State University in 2003, where he later received a Bachelor of Science in Environmental Engineering degree during the spring semester of 2007. After graduation, he spent the 2007 summer at Harbor Branch Oceanographic Institute in Fort Pierce, Florida, where he studied gas transfer in air-lifts for recirculating aquaculture systems. In the fall of 2007, Ryan accepted a graduate research assistantship position with Louisiana State University to continue his educational success, which was funded through Hubbs SeaWorld Research Institute in San Diego, California, and the United States Department of Agriculture. Ryan is presently a candidate for a Master of Science in Civil Engineering degree.